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Contents

SILICON CHIP

Vol.25, No.4; April 2012 www.siliconchip.com.au

Features

36 Why Is The 50Hz AC Mains Waveform Distorted?
Theory tells us that the 50Hz AC mains waveform is a pure sinewave but in practice it's often distorted because the peaks have been clipped off. Here's why – by Leo Simpson

42 Review: MikroElektronika EasyPIC v7 Development Board
It provides an easy way to program & debug 8-bit PIC micros & can be used with the C, Pascal & BASIC programming languages – by Nicholas Vinen

80 Q & A On The Maximite Microcomputer
A look at the six most common problems encountered by constructors plus some questions & answers on this popular design – by Geoff Graham

Projects To Build

16 1.5kW Induction Motor Speed Controller, Pt.1
Versatile unit will drive virtually any modern 3-phase induction motor or any single-phase motor that does not contain a centrifugal switch. It's rated at up to 1.5kW (2HP) & can control speed over a wide range – by Andrew Levido

28 SoftStarter: Taming The Surge Current Menace
Do you get a juicy "splattt" from your mains power point when you plug in a large plasma TV set or some other piece of gear? Our SoftStarter solves this problem while having no effect on appliance performance – by Nicholas Vinen

38 A 6-Decade Resistance Substitution Box
It's easy to build and lets you select from thousands of different resistance values between 10Ω and 10MΩ using six rotary switches. When you have found the optimum, just read off the value on the switches – by Jim Rowe

60 Ultra-LD Mk.3 135W/Channel Stereo Amplifier, Pt.2
Second article on our new high-performance stereo amplifier completes the assembly and describes the test & adjustment procedure – by Greg Swain

Special Columns

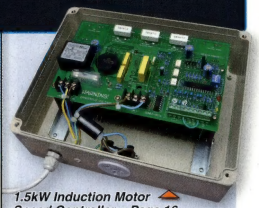
54 Serviceman's Log
The earthquakes finally killed my TV set – by the Serviceman

70 Circuit Notebook
(1) Using Mosfets For Reverse Polarity Protection; (2) Simple Water Level Alarm; (3) 433MHz Garage Door Position Monitor; (4) 12/24V Vehicle Instrument Panel

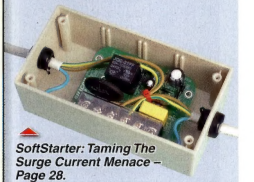
82 Vintage Radio
Philips 196A 4-valve portable receiver – by Rodney Champness

Departments

2 Publisher's Letter
4 Mailbag
53 Product Showcase
89 Order Form
90 Ask Silicon Chip
94 Notes & Errata
95 Market Centre



1.5kW Induction Motor Speed Controller – Page 16.



SoftStarter: Taming The Surge Current Menace – Page 28.

6-Decade Resistance Substitution Box – Page 38.

Ultra-LD Mk.3 135W/Channel Stereo Amplifier, Pt.2 – Page 60.

Note: part 3 of the SemTest has been held over until May 2012.

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Publisher's Letter

Induction motor speed controller an intriguing design exercise

This month we are very pleased to present the first article on an Induction Motor Speed Controller. For years we have had requests for just such a project but we have always had to decline on the grounds that we did not really have sufficient expertise in this area. In fact, I was probably being too conservative in this regard because we had already produced a similar project of greater complexity some 20 years ago in a 5-part series on a 2kW sinewave inverter, between October 1992 and February 1993. That project was quite advanced for its time and did not have the benefit of a fancy microcontroller. In fact, that sinewave inverter was produced at a time when such products, particularly of that high rating, were rare and very expensive.

By contrast, these days variable speed drives (VSDs) for induction motors are very common but they are still relatively expensive. Having said that, variable speed drives for single-phase induction motors are still not common. Now though, we have a design which will drive both 3-phase and single phase induction motors with name-plate ratings up to 1.5kW (2 HP). And while its most popular use will probably be to enable power savings with swimming pool pumps, it will also be of considerable interest for enthusiasts who wish to run lathes and other machinery over a wide speed range.

The whole concept of induction motor speed control is intriguing to anyone with an understanding of how these motors work. Tesla, the inventor of the induction motor, was definitely a genius and his concept of the rotating magnetic field (in a 3-phase motor) is such an elegant concept. So if you understand how an induction motor is effectively locked to the mains frequency, it becomes clear that simply reducing the voltage is not enough to vary the speed; the frequency must also be altered.

And while we have understood the concepts well enough, the idea of being able to control a 3-phase or single-phase 230VAC induction motor when you only have an input of 230V, and thereby 325V DC, is yet another hurdle. This design does it by a very clever technique. First, it makes the assumption that any 3-phase motor with a rating of less than about 2kW can be connected in delta configuration and this means it can be driven with 230VAC rather than 400VAC (equivalent to 415VAC with a 240VAC single-phase mains supply).

Second, the design manages to obtain a sinusoidal 230VAC between each phase. That is a big leap because how can you manage to obtain more than 115VAC (sinusoidal) by pulse-width modulation from a 325V DC bus? And if you only have 115VAC coming from each of the three phases, how can you possibly obtain sinusoidal 230VAC between phases when you can only expect 200VAC (ie, 1.732 x 115)? The answer turns out to be by not generating sinusoidal phase voltages. Instead, they are deliberately distorted (or squashed) by the addition of the third harmonic. The resulting inter-phase voltage IS sinusoidal and it is 230VAC.

Some people will regard this a technical skulduggery but it works beautifully. Not only that, but by setting a frequency range of 1Hz to 75Hz, the controller gives a speed range from very low to very fast; much faster than an induction motor can run at its nominal mains frequency of 50Hz. For example, an induction motor with a name-plate rating of 1440 RPM will have a theoretical speed range from less than 30 RPM to around 2160 RPM, albeit with reduced power if not running at 50Hz.

There is much more to the story, beginning on page 16 of this issue. I hope that you find it as intriguing as we have. Thanks to Andrew Levido for his clever design.

Leo Simpson

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God-like semiconductor gurus stand in judgement

I saw the first article on the SemTest semiconductor test set in the February 2012 issue. So why is Jim Rowe spouting that silly line that BJTs are "current operated" and FETs are "voltage operated"? That is soooo last century.

What does it really mean? Is it really true? I don't believe so and I cite as expert witnesses Peter J. Baxandall and Douglas Self. PJB is, like, God, so you know I'm right. Horowitz and Hill only ever talk about either in terms of transconductance.

The input variable for BJTs, FETs, and IGBTs is the base-emitter or gate-source voltage, and the output variable is the collector or drain current. In fact, the same model should adequately describe thermionic valves too. What distinguishes all these devices is the magnitude of their various parameters.

BJTs would better be described as low-input-impedance high-gain transconductance devices and FETs as high-input-impedance low-gain transconductance devices. The primary gain parameter of a BJT is its "g_m" and that of a FET is its "g_fs".

But wait! What's this? On page 45 under "Testing Mosfets" you write that BJTs are "transadmittance device[s]"? And what is transadmittance? It's the complex form of transconductance, ie, the ratio of output current to input voltage. In what sense can that be called "current-controlled"? Maybe you're a bit confused. I certainly think this mode of thinking is confusing.

Does this mean the SemTest doesn't do a proper job of measuring BJT gain? No. The fantastic thing about BJT transconductance is that it is determined by physics and its collector current. It is so well described by the Schockley diode equation, that they form the basis of log and antilog amplifiers that operate with precision over six to eight decades of current. There is simply no need to measure BJT transconductance.

FETs are another matter entirely, since their transconductance can be affected during manufacture. Curiously, diodes don't follow the Schockley diode equation as well as BJTs.

The SemTest looks like a thoroughly comprehensive instrument. What took you so long?

Phil Denniss,
Darlington, NSW.

Jim Rowe remains defiant: you can quote all of your God-like gurus if you like but I still stand by my simplified explanation of BJTs as a current-controlled device, as most people still think of them this way in practice. What's more, most people still use current gain or h_{FE} as the most useful "quick measure" of a BJT's health and its suitability for the majority of practical applications.

Time for 12V lighting in houses?

Is this a crazy idea with an obvious flaw? Your 10W LED floodlight project in the February 2012 issue got me thinking. I thought a couple of those would be great to replace the two 48W CFLs in my shed. Just plug a computer type 12V DC power sup-

Valuable skills are being lost

After reading Chris Ryan's letter in the March 2012 issue, I feel I have to express my opinion about another issue in today's world of recycling and reusing every-day products. As a teacher and trainer, I see students of many ages and experience. Most are simply looking to further their own knowledge and gain the required qualifications in a given area of expertise. Some attend classes because they would lose benefits if they did not but overall, most of those I see are in what is termed the "upper age bracket", ie, students over the age of 30.

I teach Automotive Electrical Theory and Basic Electronics, most of which is taken by those seeking a Certificate 2 or Certificate 3 as an additional qualification. What galls me is this: what has happened to the 16-year old students I used to teach? Where have all the apprentices gone?

At one time, all my students were apprentices, holding down jobs, attending college and squeezing in additional studies wherever possible. Now I see older students who are adding to their list of qualifications or those who attend because they must. It seems our younger people no longer have the drive to achieve qualifications or to better themselves and provide a service to those of us who have no idea how things work and don't want to know.

A friend of mine recently passed away. He was a machinist. One day, he caught me mowing and remarked that he could repair my coughing and smoking mower. He returned the mower a few days later telling me he had machined a new piston, machined the barrel, made the gaskets needed for reassembly, made the various seals etc and even found and modified new piston rings. He did a wonderful job and that mower still runs like a dream five years after he repaired it.

With all his skills and knowledge, it should have been an honour for a student to be taken under his wing and to absorb whatever knowledge was passed over to him. Alas, all that skill and knowledge has now been lost.

Dave Sargent,
Maryborough, Qld.

ply into a power point and chain two or three 10W LED floodlights off it. Then I thought, why stop at the shed? Maybe power-efficient LEDs have gotten cheap enough that its no longer necessary and appropriate for lighting to be based on 240VAC.

All the lights in your house are on a separate circuit, right? So you disconnect the lights circuit in your house from its circuit breaker in the meter box, connect a 12VDC power supply to that circuit instead and replace all the 240VAC light bulbs in your house with LED lights like the 3.6W K318s that Oatley Electronics sell for $6 each.

Sure, you'd have to disconnect the circuit safely but it'd mean you'd have very power-efficient lighting with long-life globes using all the existing wiring and switches already in the house. And you could maybe go one step further and run the light circuit off a battery that's charged off a solar panel – they're getting cheaper – with an automatic switch-over to the 240VAC to 12VDC power supply if the battery charge level dropped too low. No rocket surgery in any of that. It's all safe low-voltage stuff only connected to the mains through a professionally-designed 12VDC power supply.

I don't know whether it's still possible to get those bayonet light socket plugs so the LED "globes" could be built onto and plugged into the existing socket. That's the thing I'd be uncomfortable with – a 15VDC maximum "globe" built on a plug that could be plugged into a socket that could have 240VAC connected to it. But by doing it the way I propose you could be sure all the bayonet-type light fittings in your house, at least the fixed ones, would only have 12V DC in them.

Gordon Drennan,
Burton, SA.

Comment: this is an interesting idea and is along similar lines to an idea suggested some years ago in a Publisher's Letter whereby, since so many electronic appliances can be run from 12V, why not have a 12V grid running through the house? Now that LEDs are getting much cheaper, your idea is more practical.

It also has a big advantage in that you could back it up with a 12V bat-

Solar panels can produce significant power in late afternoon

Gordon Drennan (Mailbag, March 2012) claims that "by about 4-5PM, no matter how many roofs have PV on them, it is producing virtually no output because the Sun is too low in the sky".

This may be true at his location but it is a very different story in Perth. It is 4:15PM as I write this, and my inverter is putting out 1.6kW on a 38°C day. Normally at this time it would be closer to 2kW but the temperature does take its toll.

My panels are mounted on a west-facing roof (the house faces east, so there is no north-facing roof space). I have panels nominally rated at 2.6kW. The peak power is normally generated at about 2PM; the highest output I have seen is around 2.3kW. In the middle of summer, there is useful output to around 6PM.

Dave Goldfinch, VK6HAF,
Mosman Park, WA.

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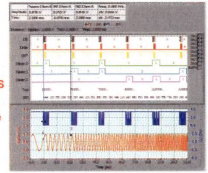

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Mailbag: continued

Comments on TV4ME & MPEG4

When I first noticed TV4ME, I could get it on most devices in my house, with the surprising exception of a late model Okano 53cm LCD TV. At the same time, I found the definition was somewhat pixellated. This was a little disappointing, given that MPEG4 should have been better.

A few days later, I tried the Okano TV again and instead of the message "No Audio, No Video" I got picture and sound. Checking on other devices I found the definition was now quite good. Had they goofed when they first set up channel 74? A friend confirmed he too had reception failures at first, now only a couple of old SD STBs fail to decode the signal.

Wenlock Burton,
Bacchus Marsh, Vic.

tery bank and then you would have less problems during a blackout. However, there are two problems with using existing switching on 12V DC rather than 230V AC. First, switch and wiring corrosion is bound to more of a problem (it's bad enough in seaside areas with 230VAC switches and power points). Second, in the event of a short-circuit, a standard 230VAC switch may not be able to break the circuit because an arc may be established across the contacts. This could be worked around by having a suitably-rated DC circuit breaker in the system.

Fisher & Paykel SmartDrive

I got a strange sense of deja vu when I read the Fisher & Paykel SmartDrive motor article in the February 2012 issue. We had done almost the same thing about two years ago, though neither of us wrote it up at the time. There were a few things we did differently and there are a few other points of interest with regard to these motors which may be of interest to readers.

We chose a winding layout similar to that described in February by Mr Stojadinovic, with two poles in series, except we used a delta configuration, which generally gives higher torque and lower speed on a lower voltage system. This decision was made on the basis that in the washing machine, the DC bus voltage was the rectified mains voltage (approx. 330V) and so each winding in star configuration would have had about 12V across it. In our experiment, we used 24V, so the two windings in series in delta configuration meant that the winding voltage was roughly the same as in the original washing machine.

The other main difference in our set-up was that we tried using the motor both with and without Hall Effect sensors (sensor-less control). When using the sensors there was better control at low speeds, however the sensor-less set-up is favoured in most BLDC designs these days, mainly due to simplicity, space and lower cost. Sensor-less control works by sensing the back-EMF produced on the undriven phase of the motor in order to determine when it is time to commutate.

At low speeds, the back-EMF can become too low to

measure accurately, causing unreliable control when the motor is moving slowly. A design of a (small) sensor-less BLDC motor controller was featured in the February 2006 issue of *Elektor* magazine.

We tried a couple of controllers, all of which were designed for the BLDC motors in electric R/C model cars and aeroplanes. These can be bought at ridiculously low prices over eBay (search for "BLDC" or "ESC"), however most of these do not support Hall Effect sensors. We also used a controller purchased from Hobby Kingdom under the "Venom" brand which did utilise Hall Effect sensors. Note, however, that many of these cheap Chinese motor controllers have very optimistic ratings and can be easily damaged. I should also mention that the BLDC motors themselves, electrically similar to the SmartDrive, are also available very cheaply and they are very good, powerful, efficient motors.

We only took a few performance measurements at the time and the original rig has since been mostly dismantled. Speed in 24V delta configuration could be varied up to about 500 RPM (in theory this should go higher), while no-load current was around 1.5-2A, rising to 20-25A when applying as much load as we could manually.

At the time we were also working on a design for a BLDC motor controller with Hall Effect sensor and sensor-less control, designed for moderately large motors (up to about 5kW). Development on this was halted about a year ago due to a hard drive failure but if there is reader interest we could revive the project.

William Andrew,
Lane Cove, NSW.

MPEG4 is permissible with DVB-T

In the Mailbag pages of the March 2012 issue, Bryce Cherry stated that MPEG4 is not permitted unless used for 3D TV. DVB-T is a technical standard, developed by the DVB Project, that specifies the framing structure, channel coding and modulation for digital terrestrial television (DTT) broadcasting. The first version of the standard was published in March 1997. Note this does not include compression standard. MPEG-2 was standardised in 1998/2000. Australia started DVB-T/MPEG-2 broadcasting in 2001 and was the only country to include HD broadcasting in DVB-T transmission. MPEG-4 was standardised in 2006.

New Zealand started DTV-T/MPEG-4 broadcasting in 2008 for all terrestrial TV, for HD and SD. Australian Standard 4599-2007 for DTV transmission includes MPEG-4. In 2010 AS4933-2010 for receivers includes the statement that broadcasters may transmit MPEG-4 compressed signals.

In my article "Digital TV: Where To From Here?" in the March 2010 issue of SILICON CHIP, there are statistics of how many models could already decompress MPEG-4. Since then all of the set-top boxes provided on the Household Assistance Scheme are all capable of MPEG-4 decompression. Additionally all Freeview Australia approved receivers are MPEG-4 capable. The current broadcast MPEG-4 compressors produce 50% less data when compared to MPEG-2 at the same picture quality. DVB-T2 was standardised in late 2010 and is capable of carrying up

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Mailbag: continued

Measure sound levels before complaining

The ever-increasing sophistication of all performances, by and large, is calling for bigger and better sound systems (these days mostly line arrays) as a contract proviso. Yes there is consultation but the supplying contractor will always defer to the producer and their company. In the case of live theatre it will be the producer that demands the volume of the PA during performance and not solely the sound engineer.

If the producer spends most of their time watching rehearsal from mid-way back in the seating, the sound level is likely set to that reference point. If you're in front of wherever the reference point is, yes it will be louder.

Some expectations for the volume levels being discussed have also been derived from increasingly sophisticated, more powerful (louder) home theatre. Home music is the same, with March's SILICON CHIP having part 1 of a 135W/channel stereo amplifier (which I imagine would be quite capable of being very loud!).

Sound has to cover all of the paying patrons, so those closer to the PA will have higher volumes (without introducing variables such as delay stacks). It seems some are more tolerant of loudness than others; that does not make them either deaf or stupid.

By all means complain to management, after you have collected dB readings around the entire room with reference quality equipment. Otherwise the observations are purely subjective.

If you are concerned about deafness caused by these volumes, don't use cotton wool; instead, use sonic earplugs that keep levels to 80dB or below.

Grant Bunter,
Batlow, NSW.

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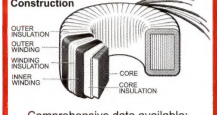

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to twice the data of DVB-T. Considering that the TV industry will lose 24 channels permanently these increases in efficiency will be required.

Alan Hughes,
Hamersley, WA.

Comment: we have been advised that about two weeks after introduction, TV4ME changed from MPEG4 to MPEG2 following market (viewer) complaints.

The introduction of TV4ME was incorrectly implemented from a transmission point of view, in that the broadcaster failed to correctly set the MPEG4 flag to ensure that only MPEG4-capable receivers would receive this service and MPEG2-only receivers would ignore it.

The MPEG4 flag was previously used in Australia during 3D transmissions of State Of Origin and World Cup

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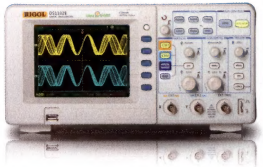

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Mailbag: continued

Braking for solar panel tracker

I just read my observations regarding limit switches in the March 2012 issue (page 6), in particular the comment at the end. In fact, I emphasise in the next paragraph the requirement for switches and any braking or steering diodes to be able to handle the motor currents involved.

While on the subject of motor braking, I think it could be safely assumed that limit switches would be used to arrest a fault condition in which a motor could be running at somewhere near full speed. In such circumstances, some form of braking would be essential as a motor could run on for quite some time and cause extensive damage.

For smaller motors, diodes are very effective but resistors can be used if diodes are a problem. I have found 10Ω 100W to be OK. If the aluminium block type can be used and attached to a metal chassis, then 50W is OK as full current only flows for a very short time.

Bob Rayner,
Willow Vale, NSW.

soccer where MPEG2-only receivers completely ignored the 3D 'Side by Side' (SBS) transmission; MPEG4 non-3D receivers displayed SBS video while MPEG4+3D capable receivers displayed a 3D image.

And contrary to popular belief, MPEG4 is possible and permissible in an MPEG2 DVB-T environment; DVB-T is very flexible in this regard. The MPEG2 video container can contain any type of video provided the receiver knows about it.

Magnetic viewing film

Those interested in permanent magnet motors, especially the Fisher & Paykel SmartDrive motor featured in February 2012 issue, may be interested in "magnetic film". This is a paper-like film (green in my case) which turns black in the presence of a magnetic field; lay it over a magnet and the poles show up very clearly.

Many of the motors like the one shown in your article have several poles superimposed on one piece of magnetic material; the magnetic film shows these poles very clearly so you can really see what is going on. Even those who are general gadgeteers will find this film useful and fun.

Several magnet supply places carry the film. Googling "magnetic viewing film" will get it but "Gaussboys" and "Applied Magnets" have it.

Quite a number of people converting these motors to wind generators have replaced the relatively weak magnets with high strength super neodymium magnets to increase the output. This should increase both the torque and output power of the motors although the back-EMF will probably change.

Arthur Davies,
Ainslie, ACT.

Limit switches for solar tracker

As Bob Rayner's letter (Mailbag, March 2012) correctly surmised, the limit switches in my solar tracker design (SILICON CHIP, January 2012) are there primarily to tell the micro when to stop and reverse the motors under normal operating conditions. They can provide limited protection against mechanical damage that might otherwise occur if the motor should attempt to drive the panels beyond their normal range of movement but that is purely a secondary function. For protection against electrical faults I would recommend a fuse.

Alternative to the arrangement used in the published circuit (or as well), a pair of limit switches could be wired directly into the motor circuit as suggested in the Editor's comment. In fact, that is an excellent idea which I have actually tried and found to work well.

If used in this manner, the switches should be connected in series with the motor and a suitably rated diode connected in parallel with each switch. Each diode should be orientated so as to block current in the direction of over-run while allowing current to flow in the opposite direction so as to permit the motor to reverse normally.

If the limit switches are used as described above then the original arrangement can be either omitted or retained, depending on the user's discretion. If the original arrangement is retained then the limit sense inputs to the micro should be shorted to 0V to allow normal operation. In this case the micro won't know that the motor has reached the limit position but the software was originally written with this possibility in mind, so this won't affect operation.

By the way, I noticed the revised MPPT solar charge controller by John Clarke in the March issue. I recall the

TV advertisements are excessively loud

Regarding the Publishers Letter in the February 2012 issue, I absolutely disagree with your view in this matter. The vast difference in volume between TV programs and advertisements is at times unbearable. You suggest turning off but I like the programs and have paid several thousand dollars to view them just like thousands of other unhappy viewers.

You suggest we ignore it and perhaps it will go away. Well, one retailer started it many years ago and now many have followed; it is getting worse and needs regulation. I don't have sufficient knowledge on this subject but would like you to feature a remedy for this, maybe a kit – perhaps part of a modified voice-controlled switch feeding into a voltage controlled amplifier. With sufficient adjustment between the two devices it could respond between fully-muted to no change.

Bill Fleming,
Launceston, Tas.

Comment: we published a stereo compressor in the January 2012 issue which will fix the problem, if you are using an external amplifier and speakers with your TV. However, if you don't have this sort of set-up then there is no technical cure, apart from using the mute button on your remote control.

More on extended warranties

I have a quick comment regarding your response to my letter on warranties in the Mailbag pages of the February 2012 issue. The new consumer laws as described in the "Australian Consumer Law" are not black and white and are particularly grey in some areas. It would be my view that extended warranties on the products previously mentioned are still worthwhile.

Say for an example, a customer purchases a 140cm television for $2000. Their first option is to purchase an extended warranty and they can then be assured it will be covered for failures within the covered time-frame – which is up to five years in most cases. This may cost the customer something like $200. Just raise a claim and the rest is easy.

If they choose not to purchase an extended warranty but rather choose to rely on the consumer laws to cover the product for any failures outside the normal manufacturer warranty, that's OK but they should keep in mind that in the event of a failure, this path would be more stressful and will almost always be costlier.

Once an item is outside the normal manufacturer warranty period, the customer will first need to get the item assessed by an approved repairer, before the manufacturer will consider helping the customer with an out-of-warranty repair. The customer is almost always up for the cost of assessment and depending on the outcome, the assessment fee may not be covered by the manufacturer at all. As a general guide the assessment may cost about $100 and this may rise to something like $150 if a call-out is required. So by this point the customer has already spent $150.

The report from the assessment is then forwarded to the manufacturer for their consideration. Depending on the age of the unit and the severity of the failure, the manufacturer may not choose to help the customer at all. Or they may choose to cover the cost of parts or in extreme cases, cover parts and labour.

If the manufacturer chooses to only cover the cost of a part, the customer would then have to pay the full labour cost. So at this point the total cost (including assessment) may have risen to something like $200 to $300, which means they have actually ended up paying more than the cost of purchasing an extended warranty.

If the outcome was thought to be less than desirable to the customer, they could then choose to take the manufacturer to court over the issue. But considering the time, stress and money involved with going down this path it would just be easier to purchase an extended warranty.

Erik Atkinson,
Neilborough, Vic.

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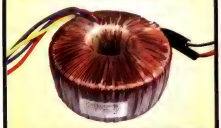
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original design, which impressed me very much. I see that John put a lot of effort into the controller. My congratulations on an excellent job done!

Herman Nacinovich,
Gulgong, NSW.

PICAXE & Arduino comparison

In regard to the question which is better, Arduino or PICAXE, I would like to add my two bob's worth. I have taught electronics (beginning with

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Parallel PIC Programmers) and senior programming classes in secondary schools (Java) over the last 20 years.

I have found the PICAXE an excellent extension for electronics classes and a good stepping stone towards understanding microcontrollers. The electronic requirements are very simple and the bootloader programming interface is just a stereo 3.5mm socket and two resistors.

My students have been constructing these computers from the blank PCB board and working through etching, drilling, soldering and debugging to a very large degree on their own. I have found that the degree of confidence and independence experienced by my students has been a hugely engaging experience and highly successful.

The PICAXE BASIC language is quite easy to learn and now that it has been upgraded, quite a capable and structurally sound language for secondary students to begin their microcontroller experience. This simple language also gives independence to students, enabling them to quickly go off and design their own projects.

However to me, it is also the weakest point in the PICAXE system as once harder programs have been mastered, quite a few senior secondary students would probably benefit from experience with a better language than BASIC.

The use of the "C"-based language in the Arduino system is a real strength. Many highly-experienced C programmers have joined the Arduino community and the Arduino IDE provides a rich source of shared libraries to work with.

This familiarity must be a real boon for people coming from the programming side of computers to the elec-

Charging mobile phones via USB

On reading the "Ask Silicon Chip" pages in the February 2012 issue, I noticed the section on recharging mobile phones in a car. I had a similar problem (a phone/iPod that would not charge via a car charger) and solved it by soldering the D+ and D- pins together inside the case of a cheap Chinese adapter. I also applied the same fix to a Jaycar 4-AA USB battery pack (Cat MP-3083).

In both cases the D+ and D- pins went nowhere on the PCB, so bridging them with solder was a minor modification with no consequence to the operation of the power supply device.

Sam Mosel,
Fullarton, SA.

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tronic side. However, I would find a problem in extending electronics classes with the standard Arduino boards such as the Uno (which is a fabulous board, don't get me wrong here) as it uses surface-mount components and a much more sophisticated electronics interface for the standard USB bootloader, as well as the C language; not really a middle school construction project.

The range of Shields (Arduino-talk for interface boards and software) now available commercially is quite staggering but their existence reinforces the notion that the CPU boards are best accepted as they are for beginners and beginners are best just playing around with the interfaces.

This is not such a bad strategy (it does have huge potential) but does not have quite the hands-on feel that the PICAXE systems provide.

Any particular school that is struggling with providing resources would baulk at the proposition that every school should use both of these systems and have the best of both worlds. Not the least because of the pressure placed on the teachers who would have to master two systems and then do the curriculum development to make them both a success in their school.

So we should not be too critical of any particular school that comes down on either side or any beginner for that matter, faced with the same choice. I believe either system could be excellent; I have no intention of igniting an Arduino-PICAXE flame war!

To sum up from a teacher's point of view, if a system is required to give middle-school students a solid microcontroller experience starting with the electronics and working through to the programming then I would highly recommend the PICAXE system. However, if I was dealing with capable year 12 students through to university level students, I would choose the Arduino system with its more advanced programming opportunities and reduced need for initial electronic construction work.

Advanced university students should be looking more at the ARM systems and other mobile, low power technologies – another stage again!

Finally, I believe that both systems should happily coexist across educational institutions, if not within them, with more emphasis on one or the other depending on the age and expectations of the learners and teachers. No doubt adult beginners are in a similar situation and as a result may find they begin with one system but after while, also use the other system from time to time, or with experience settle on just one system.

Beginners of all ages will initially begin with the standard IDEs and board configurations, as a safe starting point, and these common configurations are what most schools will judge the systems on. So suggesting a lot of technical work-arounds to my views above will be unlikely to be very attractive if they use non-standard and less well supported hardware/software combinations that vary greatly from the substantially documented mainstream concepts.

As the saying goes, "Horses for courses". We are lucky to have such excellent alternatives.

Rob Ward,
Lake Tyers Beach, Vic. SC

Solar panels generate less power when hot

I may have the answer for Will McGhie and his solar panels (Mailbag, February 2012). I recently had a 1.5kW system installed with a 2.2kW inverter and on a hot summer's day I only see 1075W.

The reason is temperature. My panels produce their rated output at 25°C. Above that the output drops off. As he lives in WA, it is perfectly understandable that he has been told that he will not see his rated 1.9kW.

However, in cooler climes the reverse is true. On a cool 19°C day I have seen an output of 1850W! The lesson here is that in cooler areas the inverter needs to be larger than the rated panel capacity.

Rowan Wigmore,
Gisborne, Vic.

Pt.1: by ANDREW LEVIDO

Here it is at last . . .

Speed Control for Induction Motors

You've asked for it many times and we have always said NO! It's too complex, too difficult, too expensive, whatever. Now we're saying YES. This Induction Motor Speed Controller is suitable for motors up to 1.5kW (2HP) and can be used to control speed over a wide range. It will save big dollars with swimming pool pumps and will be great for running machinery at different speeds. Even better, it will control 3-phase motors as well!

WE HAVE PUBLISHED quite a few speed controllers over the years, some suitable for DC motors and others for universal AC motors. Up until now, we have not published a design suitable for the most common type of AC motor of all – the induction motor.

Controlling the speed of induction motors is not easy; you cannot simply reduce the voltage and hope that it works, for two reasons. First, an induction motor's speed is more or less locked to the 50Hz frequency of the 230VAC mains supply; so reducing the supply voltage doesn't work. Second, induction motors don't like reduced supply voltage; it makes them difficult to start and there is the risk of burnout.

Features & Specifications

Features

- Controls single-phase or 3-phase induction motors
- Runs from a single-phase 230VAC, 10A power point
- Over-current, over-temperature, under-voltage, over-voltage and short circuit protection
- EMI (electromagnetic interference) filtering for reduced radio interference
- Inrush current limiting
- Isolated control circuitry for safety
- Can be mounted in an IP65 sealed enclosure
- Adjustable speed ramp up/down
- Pool pump mode
- Can run 3-phase motors in either direction
- Optional external speed control pot with run, reverse and emergency stop switches
- Motor run/ramping and reverse indicator LEDs
- Fault indicator LED
- Open collector output provides either fault or up-to-speed indication

Specifications

Motor power: up to 1.5kW (2 horsepower)
Maximum output voltage (single or 3-phase motor): ~230V RMS
Continuous output current: 8.5A RMS (single-phase), 5A RMS (3-phase)
Short-term overload current: 13A RMS (single-phase), 7.5A RMS (3-phase)
Switching frequency: 16kHz
Quiescent power: 28W
Speed ramp period adjustment: 3-30s to full speed
Continuous input current: up to 8.7A RMS
Speed control range: 1-100% or 1-150% (0.5Hz to 50Hz or 75Hz) in 0.05Hz steps
Efficiency: up to 96%
Speed control signal: 0-3.3V
Up-to-speed/fault output sink: 12V/200mA

No, the only reliable way of controlling the speed of an induction motor is to vary the drive frequency. As we shall see, it is also not enough to simply vary the frequency; as the frequency drops below 50Hz, the applied voltage must be reduced proportionally to avoid magnetic saturation of the core. This makes the electronic circuitry complex and its design is made more difficult by the wide variety of induction motors.

Fortunately, advances in power semiconductors have reached a point where such a project is now viable. But our previous objections still apply. It is complex, relatively expensive and potentially dangerous.

This project is only recommended for experienced constructors. Most of the circuit is at 230VAC mains potential and worse, it has sections running at 325-350V DC. Furthermore, the circuit can remain potentially lethal even after the 230VAC mains supply has been disconnected.

We envisage the main application of the speed controller will be in reducing the energy consumption of domestic pool pumps – one of the biggest single contributors to the power bills of pool owners. We've previously published a review of a commercial unit that does this but at a price tag of over $1000. You should be able to build this unit for a couple of hundred dollars, making it a much more attractive proposition.

That said, we have tried to make this unit fairly versatile. It will drive virtually any modern 3-phase induction motor or any single-phase motor that does not contain a centrifugal switch, rated at up to 1.5kW (2HP).

In this first article, we describe the features of the controller and explain how it works. A following article will detail the construction, testing and installation.

Induction motors

Invented in the 1880s by the Croatian engineering genius Nikola Tesla, the induction motor has become the most common type of electric motor in use today. According to Tesla, the concept came to him in a vision while he was walking in a park in Budapest in 1882. The vision was so vivid and detailed that he was able to construct a working prototype completely from memory.

Since we don't all have Tesla's powers of memory and visualisation, a quick refresher on induction motor principles is probably in order. A set of windings in the stator, fed by a 3-phase voltage supply, produces a rotating magnetic field. This field induces (by transformer action) a corresponding current in a set of short-circuited windings in the rotor. These rotor currents create their own magnetic field that interacts with the stator's rotating field to produce torque that turns the rotor and any attached load.

Things are more tricky in the case of single-phase induction motors since with one winding we can only produce a pulsating field. This can induce current in the rotor but unless the rotor is already turning, there will be no torque. Single-phase induction motors must therefore have a separate start winding.

This start winding is usually connected via a capacitor and/or a centrifugal switch. **Some of these motors are not suitable for use with the speed controller described here. Please refer to the panel later in this article for specific information.**

Shaded Pole and Permanent Split Capacitor (PSC) types, which includes most domestic pumps, fans and blowers, should be fine.

The ubiquity of induction motors is a result of their low cost and high reliability. Unlike DC or universal motors, there are no brushes or slip-rings to wear out or be adjusted. The stator is constructed like a standard mains transformer, with a laminated steel core and conductive windings.

In most cases, the rotor "windings" take the form of aluminium bars cast into slots in the surface of the rotor laminations, running parallel to the shaft. Conducting rings cast around either end of the rotor short these bars,

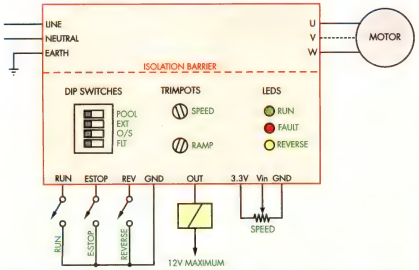


Fig.1: overview of the Induction Motor Speed Controller. The mains input power (left) and the motor (right) are connected to the high-voltage section at top, with the earth connection is used for EMI suppression. The DIP switches and trimpots allow the unit to be configured while the LEDs provide feedback. The optional external controls (shown at bottom) may be attached when the application requires them.

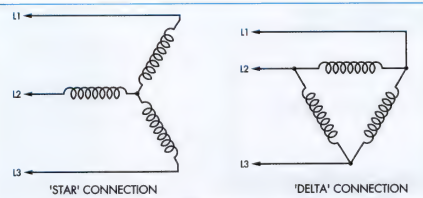


Fig.2: the windings of small 3-phase motors are normally connected in star configuration for use with the 400V RMS 3-phase mains supply. In this case, each winding is driven with the phase-to-neutral voltage of 230V. By changing how the windings are connected (which can usually be done by moving some jumpers), the motor can be changed to delta configuration, with just one winding between each phase. It can then be driven from a 230V RMS 3-phase supply such as the output of this motor controller.

forming a cylindrical cage around the rotor – hence the term "squirrel cage motor".

So the rotor is effectively a solid lump of metal, making for an extremely rugged and low cost motor.

Features

Refer now to Fig.1 for an overview of the 1.5kW Induction Motor Speed Controller. The input is 230V 50Hz single-phase mains and the output is either a single or 3-phase supply with a frequency variable between 0.5Hz and 50Hz (or 0.5Hz and 75Hz) and a voltage between almost zero and 230V RMS. The output voltage tracks the frequency linearly, except at very low frequencies, when a little extra is applied to help overcome the voltage lost across the stator winding resistance.

The 3-phase output produces 230V RMS, measured between any two of the three outputs. So it doesn't matter which two outputs a single-phase motor is connected to, it will receive 230V regardless.

The output frequency and voltage is controlled either by an on-board trimpot or using an external potentiometer or voltage source. This is selected by a DIP switch labelled "EXT".

To start the motor, the Run terminal is pulled to ground whereupon the motor will ramp smoothly up to the preset speed. If the Run terminal is opened, the motor will ramp back down smoothly to a stop. If the Run terminal is hard wired to ground, the motor will start ramping immediately power is applied.

The rate at which the motor ramps up and down is set by a second onboard trimpot. The ramp is adjustable from 3-30 seconds, for a full ramp from 0.5Hz to 50Hz.

It is important to set this rate sufficiently long, particularly if the load has high inertia. If the acceleration is too fast, the motor will draw very high current and trip the over-current protection. This occurs because the rotor does not have time to "catch up" with the rotating magnetic field.

Similarly, decelerating a high inertia load too quickly can cause an over-voltage trip. This can occur if the load overtakes the motor, causing it to regenerate too much energy back into the controller.

A green LED indicates when the motor is running. This flashes while the motor is ramping to or from the set speed and lights solidly when the set speed is reached.

If the Reverse terminal is pulled low, the direction of rotation will change. This only works for 3-phase motors, since the direction of single-phase motors is fixed by the wiring of their start circuit. If the motor is running while this input changes state, the controller will ramp down to zero then ramp back up again in the opposite direction. A yellow LED lights to indicate the motor is running in reverse.

A single open-collector output (OUT) is provided to drive an external 12V relay or lamp. This output can be programmed via the "FLT" DIP switch to pull down either when the motor reaches the target speed or when a fault event occurs.

The AC motor speed controller also has fault protection circuits to protect it against over-current, over-voltage and over-heating. An external source may also trigger a fault condition by pulling the ESTOP terminal low.

The over-current protection monitors the current through the output devices and signals a fault if it approaches the device limits. The over-

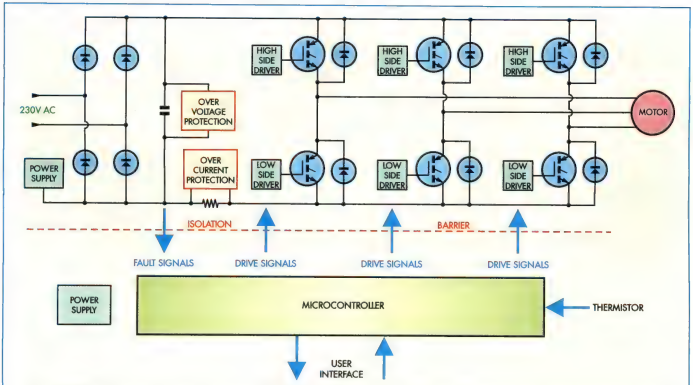


Fig.3: this block diagram shows how incoming 230V AC mains is rectified and filtered before being applied to the motor by six IGBTs configured as a 3-phase bridge. The capacitor bank voltage can increase during over-run and the over-voltage protection circuit disables the IGBTs before damage can occur. The over-current protection prevents damage in case of overload or a shorted output, while a thermistor shuts it all down if the heatsink gets too hot. The micro is isolated from the high-voltage circuitry by opto-couplers.

voltage protection detects excessive voltage rise caused by energy being fed back into the motor terminals by regeneration. As you would expect, the over-heating protection is triggered if the heatsink temperature rises to an unacceptable level.

When any of the above faults occur, the output devices switch off and the red LED lights. The fault condition remains latched until the source of the fault is cleared and either the run switch is opened or the power is cycled off and on.

There is also an over-speed option, which is selected using the "O/S" DIP switch. When this is enabled, the output frequency goes up to 75Hz rather than 50Hz. However, the maximum voltage of 230V is achieved at 50Hz and does not increase further with higher frequency. This allows motors to be run at 50% above their normal speed but with decreasing power and torque.

Pool pump mode

We expect the most common application for this controller will be to reduce energy consumption of domestic pool pumps. Most pool pump motors are PSC (Permanent Split Capacitor) types and so eminently suitable for use with this speed controller.

Running your pool pump at around 70% of rated speed can result in significant energy (and cost) savings with little or no impact on the effectiveness of the filtration. Various commercial products are available to do this job but this unit should cost less to build and has some other advantages such as less radio frequency interference.

Pool pumps ideally require a short period of running at full speed when first switched on, so that the pump seals warm up and the full flow of water can push out any air which may

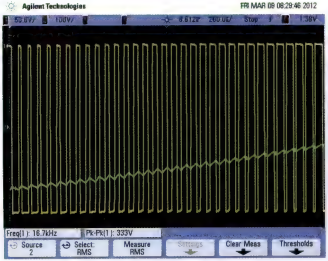
WARNING!

This circuit is directly connected to the 230VAC mains. As such, most of the parts and wiring operate at mains potential and there are also sections running at 325-350V DC. Contact with any part of these non-isolated circuit sections could prove FATAL (see Fig.6).

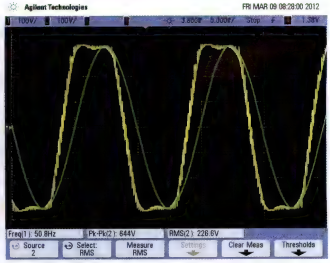
Note also that the circuit can remain potentially lethal even after the 230VAC mains supply has been disconnected!

To ensure safety, this circuit MUST NOT be operated unless it is fully enclosed in a plastic case. Do not connect this device to the mains with the lid of the case removed. DO NOT TOUCH any part of the circuit unless the power cord is unplugged from the mains socket, the on-board neon indicator has extinguished and at least three minutes have elapsed since power was removed (and the voltages have been checked with a multimeter – see text).

This is not a project for the inexperienced. Do not attempt to build it unless you are familiar working with high-voltage circuits.



Scope1 (200µs/div)



Scope2 (5m/div)

These two scope grabs show the output waveforms with the motor speed controller set at full speed (ie, 50Hz). The yellow traces show the voltage at one of the outputs while the green trace shows the voltage between it and another output, ie, the inter-phase voltage. The inter-phase voltage is measured using an RC low-pass filter (8.2kΩ/33nF).

Scope1 has a faster time base and only shows a portion of the sinewave along with the PWM pulses. Its peak-to-peak amplitude of 333V corresponds with the DC bus voltage; our mains voltage was around 233V at the time this was captured.

Scope2 uses a time base which is too slow to show the individual 16kHz PWM pulses, so the scope shows the average voltage instead, with some switching pulses still visible. Compare this waveform to the theoretical shape shown in Fig.3 and you will find that they are quite similar.

The inter-phase sinewave peak-to-peak voltage (644V) is nearly double the peak-to-peak voltage of the PWM waveform (333V), as we expect. The measured RMS voltage of 226.6V is very close to what we would expect (227.7V RMS).

The actual sinewave frequency is slightly above 50Hz, due to microcontroller's internal RC oscillator tolerance of ±2% (-40 to 85°C), giving a frequency range of 49-51Hz for full speed.

have accumulated in the system. We have designed the Induction Motor Speed Controller with a special pool pump mode that first ramps the motor up to full speed and holds it there for 30 seconds, before ramping down to the preset level.

Right at the point of starting, the motor receives a little extra voltage to help overcome the stiction that can occur when the pump seals are cold. During the 30-second hold time, the green LED remains on but flickers quickly.

3-phase motors

You may be wondering how a controller with 230VAC input and output can drive 3-phase induction motors, since these are normally rated for a 400VAC supply (415VAC with 240VAC mains).

Fortunately, most 3-phase induction motors rated up to about 2.2kW actually have 230V windings. These are normally wired in "star" configuration (Fig.2), with two windings between consecutive phases for 400V operation. With a balanced load, the star junction voltage is near neutral potential and so each winding is driven with the phase-to-neutral voltage, 230V RMS.

Alternatively, these motors can be run in "delta" configuration, with one winding between consecutive phases, for operation with single-phase input 3-phase inverters like this one.

The wiring change to reconfigure a motor from star to delta is made by repositioning a set of jumpers inside the motor's terminal box. The jumpers come with the motor and there is usually a diagram of their configuration on the motor rating plate or on the inside of the terminal box cover.

With the speed controller's DC "bus" at a nominal 325V, each phase voltage is limited to 325V peak-to-peak, or 115V RMS if we generate a pure sinewave. This would give us an inter-phase voltage of:

115V x √3 = 200V RMS.

However, it is possible to generate the required 230V RMS sinewave between the three phases by deliberately making making each phase output non-sinusoidal. We do this by adding the third harmonic, as shown in Fig.4. The resultant "squashed" sinewaves from each output give pure phase-to-phase sine waves with voltages of 650V peak-to-peak or 230V RMS.

How it works

Fig.3 is a block diagram of the AC Speed Controller showing the basic building blocks. The mains is rectified and filtered to provide the DC bus of about 325V. This feeds a 3-phase bridge of six IGBTs (insulated gate bipolar transistors) which pulse-width modulate the DC bus to synthesise sinusoidal phase-to-phase voltages. The switching frequency is 16kHz and the inductance of the motor filters this waveform to produce a motor current that is almost purely sinusoidal.

The modulation applied to each output is actually a mixture of two sinewaves, one at the desired frequency and one with a lower amplitude at

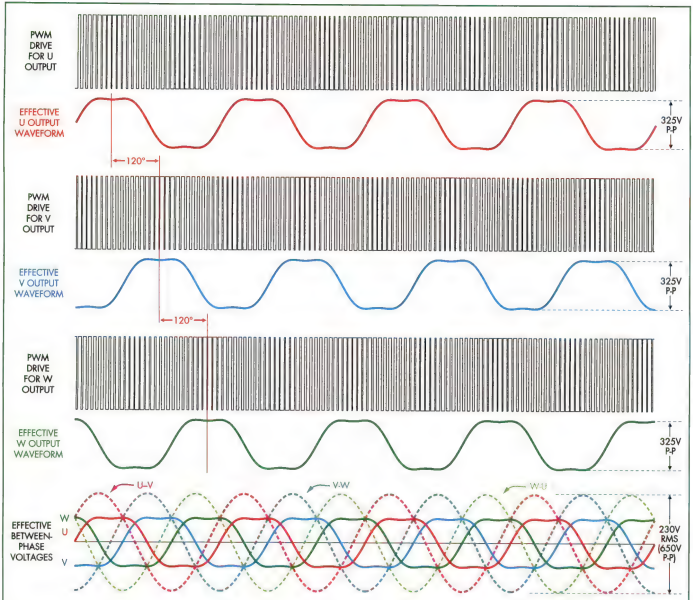


Fig.4: in operation, 16kHz PWM is used to generate identical waveforms with different phases from all three outputs (U, V & W). The motor winding(s) are connected between these outputs and so are driven with the difference between them. When we subtract these wavforms from each other, the result is three 230V RMS sinewaves, also 120° out of phase. To reverse the motor, the controller simply swaps the phase of two of the outputs.

three times that frequency (ie, its third harmonic). The waveform generated by each pair of IGBTs is identical but displaced from the others by 120°. The phase sequence can be swapped by the microcontroller to reverse the direction of the motor's rotation.

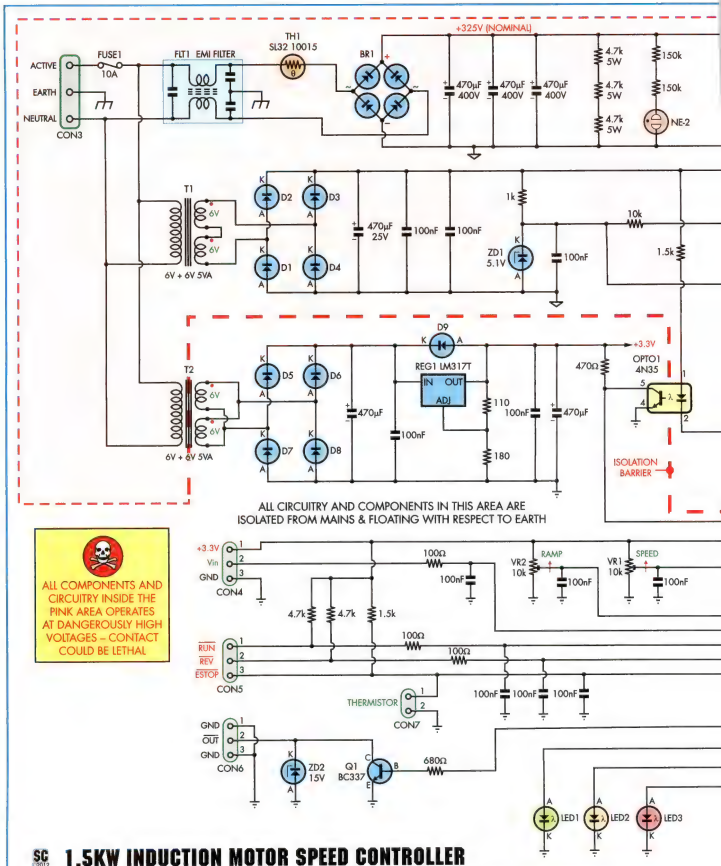
The third harmonic is unaffected by this displacement as 3 x 120° = 360°. Since the windings are connected between output pairs, it cancels out and the voltage across each winding varies in a purely sinusoidal fashion. The third harmonic component exists only to allow us to increase the modulation to provide 230V RMS without clipping the peaks (see Fig.4, above).

For a 1.5kW single-phase induction motor, the normal full-load current is over 8A RMS. Allowing for a 50% margin and taking into account the peak current, the output switches must therefore be capable of switching about 18A. This presents a formidable design challenge. We need output devices capable of switching at 16kHz, rated for 600V and nearly 20A continuously. The diodes across the switches must be similarly rated.

The low-side IGBT drivers are referenced to the negative line of the DC bus but the high-side drivers must float on their respective output line and these are switching up and down at high speed In addition, we need to monitor the DC current and voltage in order to protect the controller from fault conditions.

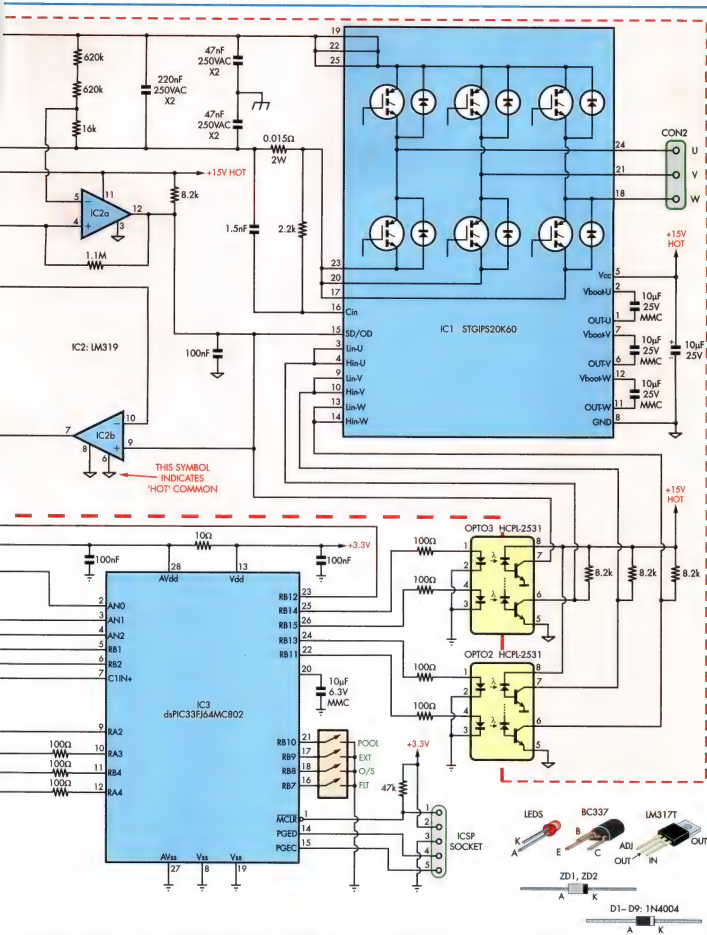
Fortunately, these days it's possible to buy a power module combining six 600V 20A IGBTs, six matching freewheel diodes, all the necessary drivers and level-shifting circuitry plus the over-current protection circuit, all for about $20. As a bonus, the whole lot is encapsulated in an isolated-base package measuring just 20 x 45 x 5mm.

This device we chose (the STGIPS-



SC 1.5KW INDUCTION MOTOR SPEED CONTROLLER

Fig.5: the full circuit diagram of the 1.5kW Induction Motor Speed Controller PCB. The incoming mains is rectified by BR1 to provide a +325V DC bus. This powers 3-phase IGBT bridge IC1 which switches the voltage to the motor via CON2. A 0.015Ω resistor in its ground path provides current feedback to CIN (pin 16) for over-current and short-circuit protection. PIC microcontroller IC3 controls the 3-phase bridge via optocouplers OPTO2 & OPTO3.


620k
620k
16k
47nF 250VAC X2
220nF 250VAC X2
47nF 250VAC X2
0.015Ω 2W
+15V HOT
8.2k
1.5nF
2.2k
1.1M
IC2a
IC2: LM319
100nF
IC2b
THIS SYMBOL INDICATES 'HOT' COMMON
IC1 STGIPS20K60
SD/OD
Un-U
Hin-U
Un-V
Hin-V
Un-W
Hin-W
Cin
Vcc
VbootU
OUTU
VbootV
OUTV
VbootW
OUTW
GND
10µF 25V MMC
CON2
U
V
W
+15V HOT
10µF 25V
100nF
10Ω
+3.3V
AVdd
Vdd
AN0
AN1
AN2
RB1
RB2
C1IN+
IC3 dsPIC33FJ64MC802
RA2
RA3
RB4
RA4
RB12
RB14
RB15
RB13
RB11
10µF 6.3V MMC
RB10
RB9
RB8
RB7
POOL
EXT
O/S
FLT
47k
MCLR
PGED
PGEC
ICSP SOCKET
AVss
Vss
OPTO3 HCPL-2531
OPTO2 HCPL-2531
100Ω
8.2k
LEDS
BC337
LM317T
ADJ
OUT
IN
ZD1, ZD2
D1– D9: 1N4004

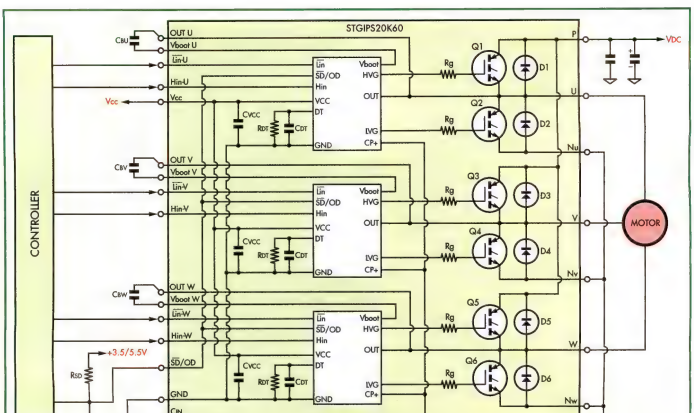


Fig.6: typical application of the STGIPS20K60 IGBT bridge, redrawn from the data sheet. Each pair of IGBTs have parallel free-wheeling diodes and drive one of the motor terminals. The associated control blocks drive the IGBT gates, generating the high drive voltage for the upper IGBT in each pair (in combination with external boost capacitors) and providing dead time during switching to prevent cross-conduction. The module also features over-current protection via the CIN input and has a shut-down input (SD/OD) which also acts as a fault output.

20K60 from ST Microelectronics) requires a 15V DC supply referenced to the negative side of the DC bus. The microcontroller and the rest of the circuitry must be optically isolated from the high-voltage circuitry and is therefore powered by a separate isolated power supply.

Circuit description

Now take a look at the full circuit diagram, Fig.5. As shown, the mains input passes through a protective fuse and EMI (electromagnetic interference) filter FLT1 before being rectified and filtered in the classical manner.

NTC thermistor TH1 is wired in series with the rectifier to limit the in-rush current when the DC bus capacitors are discharged. This thermistor has a resistance of about 10Ω when cold, limiting the peak current to 35A. As the thermistor begins to conduct, it heats up and its resistance drops dramatically. When conducting 8A, its resistance is around 100mΩ.

The EMI filter is included to help minimise the conduction of noise back onto the mains. EMI is a major issue for drives of this kind because the very fast switching of very high voltages generates a lot of electrical noise. Thanks to this filter and the other precautions taken with this design, the radio interference produced by this design is significantly lower than that of commercial equivalents we have tested.

The DC bus is filtered by three 470μF 400V electrolytic capacitors. **These capacitors store an enormous amount of energy and they could remain charged to lethal levels for many minutes after the power is removed.** We have added a series string of three 4.7kΩ power resistors across the bus to discharge it. Even so, it takes a minute or so for the bus to discharge to a safe level.

As further protection, a neon lamp is wired across the bus to indicate the presence of dangerous voltages. You should not attempt to work on this circuit even when the power is removed unless the neon is out. Even then you should check with a multimeter!

Incidentally, two 150kΩ resistors are used in series with the neon because one standard 0.25W resistor does not have sufficient voltage rating.

The 220nF X2 capacitor across the bus provides a low-impedance path for differential-mode noise, while the two 47nF X2 capacitors serve a similar function for common-mode noise. These are also part of the EMI suppression, as well as providing a high-frequency bypass for the DC bus.

The DC bus current is monitored by a low-inductance surface-mount

0.015Ω 2W shunt resistor. The voltage across this resistor is filtered by a 2.2kΩ resistor and 1.5nF capacitor before being fed into pin 16 of the power module, IC1. When this input reaches +0.54V (corresponding to about 36A), it immediately shuts down the IGBTs and signals an over-current fault.

IC1 requires a 15V supply (+15V_{HOT}) referenced to the negative leg of the DC bus. The 10µF capacitor between pins 5 & 8 of IC1 decouples this supply, right at the point it enters IC1.

Three 10µF capacitors are required for the high-side driver bootstrap power supplies. These capacitors are charged from the +15V_{HOT} rail via diodes inside IC1 each time the low-side IGBTs turn on. They provide a high-side power rail floating on each of the output terminals. We selected low-cost surface-mount ceramic types in 0805 packages for these capacitors since they must have very low impedance.

Each of the six output switches can be controlled independently but the STGIPS20K60 allows for the high and low-side inputs to be connected, so that only three control lines are required. When these signals change state, an internal dead-time circuit inside IC1 ensures that the upper and lower IGBTs never conduct at the same time.

The three inputs are driven from the microcontroller via high-speed HCPL-2531 optocouplers (OPTO2 & OPTO3) and associated 8.2kΩ pull-up resistors. High-speed optocouplers with well-matched turn-on and turn-off times are necessary as the switching pulses become very narrow when the duty cycle of the modulation approaches 0 or 100%.

Pin 15 of the power module (IC1) is both an input and output. If an over-current or other fault is detected within IC1, it pulls this pin low. It also monitors the voltage on this pin and shuts down the power stages if it is driven low externally. Thus, the micro can pull this line down to shut off the IGBT bridge.

In our case, pin 15 can be pulled low by the open-collector output of the LM319 dual comparator, IC2a. This comparator compares the DC bus voltage (via a voltage divider) with a 5.1V reference derived from ZD1 and associated components. If the DC exceeds 400V, a fault is triggered. The 10kΩ and 1.1MΩ resistors provide some hysteresis for this comparator.

Pin 15 can also be pulled low by the microcontroller via one half of the high-speed optocoupler pair OPTO3.

The other half of the LM319 dual comparator, IC2b, is used to monitor the voltage at pin 15 of IC1 and signals the microcontroller via 4N35 optocoupler OPTO1 if it falls below +5.1V. This tells the microcontroller that one or other of the protection circuits described above has been activated and that the IGBTs have been switched off.

The +15V_{HOT} supply is derived via a conventional rectifier (D1-D4) and filter capacitors from the 12V AC produced by transformer T1. This supply is effectively at 230VAC mains potential, so a second isolated supply is required for the control circuitry. Transformer T2 and the associated rectifier (D5-D8) and 470µF filter capacitor provide about +8V DC to LM317T linear regulator REG1 which in turn drops this to the +3.3V required by the microcontroller.

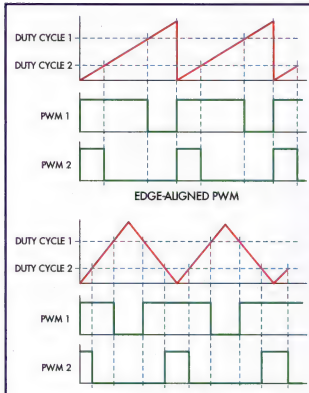


Fig.7: this diagram illustrates the difference between traditional edge-aligned PWM and centre-aligned PWM (also known as dual-ramp PWM). With centre-aligned PWM, the leading edge of each pulse moves as the duty cycle changes. This is an advantage because if all outputs switch high at the same time, as with edge-aligned PWM, the total current pulse is larger and so more EMI is generated.

Microcontroller

The microcontroller (IC3) is a Microchip dsPIC33FJ64MC802. This is a 16-bit device with 64k bytes of flash and 16k bytes of RAM. The letters MC in the part number indicate that it is optimised for motor control applications. More on this later.

The micro requires all the usual supply bypass capacitors. The 10µF capacitor connected to pin 20 is the bypass for the 2.5V CPU core power supply. This has to be a low impedance type and mounted close to the device pins. We used a surface mount ceramic chip capacitor here.

The analog parts of the micro are powered from the AVdd pin so this is connected to a low-noise 3.3V supply filtered by a 10Ω resistor and100nF capacitor. This low-noise 3.3V rail also feeds trimpots VR1 & VR2.

Pins 2, 3 & 4 on IC3 are connected to the microcontroller's ADC and read the internal speed, ramp rate (trimpots VR1 & VR2) and external speed potentiometer setting (from CON4) respectively. The 100nF capacitors on these inputs provide a degree of filtering.

The RUN and REV (reverse) terminals at CON5 are connected to digital inputs on the micro via simple RC filters. These are active-low inputs with 4.7kΩ resistors to pull the lines high when the terminals are open.

An NTC (negative temperature coefficient) thermistor connected to CON7 monitors the heatsink temperature. At room temperature, the thermistor has a resistance of about 10kΩ and together with the 1.5kΩ resistor, forms a voltage divider, presenting about +3.0V at pin 7 of IC1. This input is configured as

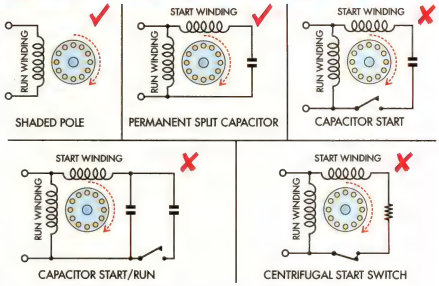
Single-Phase Induction Motors

With a 3-phase supply, achieving a rotating magnetic field is simple since three windings can be positioned around the stator so that the resulting field "drags" the rotor around. Swap any two of the phases and the field will rotate in the opposite direction.

With a single-phase supply, there is only one winding and this can only produce a pulsating field. There is no torque on the rotor when it is stationary, so it cannot start without some impulse to get it going. Once moving, the torque builds up and there is no further problem. Of course, the motor will rotate equally well in either direction, depending on the sense of this initial kick. You can't change the direction of these motors electrically, like you can with 3-phase types.

There are quite a few different schemes used to give this initial kick-start. Manufacturers have not adopted a common set of terms to describe their various approaches, so the whole topic is potentially confusing.

Below, we have summarised a few of the more common starting mechanisms, together with their characteristics and applications:



Shaded Pole ✔

A shorted turn on the corner of the stator poles distorts the magnetic field to create a weak starting torque. Shaded pole motors are inefficient due to the shorted turn and so usually limited to low power motors such as found in small domestic fans and blowers. These motors can be used with a speed controller such as the one described here but generally that would be an expensive solution for a low-power device.

Permanent Split Capacitor (PSC) ✔

A start winding in series with a capacitor produces a second, weaker field slightly out of phase with the main field. The capacitor and start winding are connected permanently so they are designed to draw a relatively modest current and are rated for continuous operation. PSC motors have low starting torque and are very reliable since there is no centrifugal switch. Typically used for fans and centrifugal (pool & spa) pumps up to about 2kW, these are suitable for use with a speed controller.

Capacitor Start ✘

These are similar to the PSC motor in that a capacitor and start winding create a phase-shifted field for starting. The capacitor is larger and the start winding designed to draw significantly more current and therefore provides a much higher starting torque. The start winding and capacitor are not necessarily rated for continuous operation and waste a lot of energy so must be switched out by a centrifugal switch, typically when the motor reaches about 70% of full speed.

They are used for conveyors, large fans, pumps and geared applications requiring high starting torque. Capacitor Start motors are not suitable for variable speed use because at lower speeds the centrifugal switch will close and the start winding and/or capacitor may burn out.

Capacitor Start/Run ✘

These are the "big guns" of single-phase motors and are used for machine tools, compressors, brick saws, cement mixers, etc. They have a large start capacitor that is switched out by a centrifugal switch and a smaller run capacitor that is permanently connected to the start winding. They have very high starting torque and good overload performance.

Unfortunately, for the same reason as the capacitor start motors, they cannot be used with variable speed drives. A 3-phase motor is recommended in these applications if speed control is desirable.

Centrifugal Start Switch ✘

Commonly used on small bench grinders and column drills, these motors arrange a phase-shifted field with a resistive winding. Again, the start winding is only rated for short, intermittent operation (due to its high resistance) and will burn out if operated frequently or continuously.

***NOTE:** in spite of the above warnings, some readers may want to try using the Induction Motor Speed Controller with motors using a centrifugal switch to energise the start winding. **The main danger is that the start winding may be burnt out if it is energised for too long, due to it being energised at prolonged low speeds.** There is also a risk that the over-current protection in the Speed Controller will simply prevent normal operation.*

an analog comparator, with a programmable threshold voltage.

As the temperature of the heatsink rises, the resistance of the thermistor drops and the voltage on pin 7 falls. If the voltage falls below +1.1V, corresponding to a heatsink temperature of about 95°C, an over-temperature fault is triggered. This fault can be triggered externally by pulling the ESTOP terminal (at CON5) low, effectively shorting the thermistor.

NPN transistor Q1 drives an external load (perhaps a relay or lamp) connected to the OUT terminal. ZD2

provides some protection for Q1 in case the load is slightly inductive. Highly inductive loads, such as relay coils, should have a clamp diode connected directly across them. The load should be limited to 200mA at a maximum of 12V.

The three indicator LEDs are driven directly from the micro via current limiting resistors, as are the LEDs in the HCPL-2531 optocouplers.

The 4-way DIP switch is connected directly to the microcontroller. Internal pull-ups on these inputs eliminate the need for external resistors. An ICSP header is also provided, allowing in-circuit reprogramming should this be necessary.

Pulse-width modulation

The dsPIC33FJ64MC802 microcontroller contains a peripheral especially adapted for motor control PWM applications. It allows the generation of various types of PWM waveforms with up to 16-bit resolution. The pulse width registers are double-buffered so the pulse width can be updated asynchronously, without any risk of glitches in the output. This is critical for the safe and smooth operation of the controller.

We have elected to use a 16kHz switching frequency, which gives us a good balance between quiet motor operation and switching losses in the output devices. We also selected centre-aligned PWM modulation instead of the more common edge-aligned PWM because this gives much better harmonic performance.

In edge-aligned PWM (see Fig.7), the outputs are all set high when a counter rolls over to zero. When the counter value reaches one of the duty cycle thresholds, the appropriate output goes low. This creates PWM with the rising edges of each channel aligned.

In centre-aligned PWM, the counter counts up for the first half of the PWM period and down for the second half. The relevant outputs are set high when the counter counts down through the duty-cycle threshold and high when it counts up through the threshold. Each resulting individual PWM waveform is identical to the edge-aligned case but none of the edges are aligned

To generate quasi-sinusoidal ("squashed" sinewave) PWM, we have to change the duty cycle for each phase smoothly, allowing for variable frequency and amplitude and having regard for the relative phases of the three outputs.

We start with a look-up table containing 512 16-bit samples of the desired output waveform (a mixture of two sinewaves with different amplitudes); the values in this table range between -1 and +1. By stepping a pointer through this table at the appropriate rate and multiplying the looked-up value by the required amplitude we can calculate the duty cycle necessary to produce variable voltage, variable frequency PWM.

We maintain three pointers into the table, initialised at the beginning, one third and two-thirds through the table respectively. They are all incremented by the same amount so they maintain this phase relationship as they move through the table, producing three waveforms displaced by 120°.

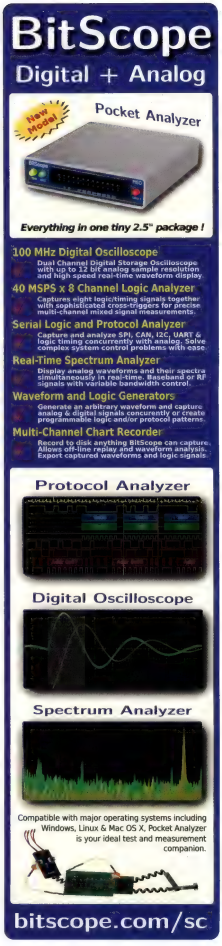
With a 16kHz modulation rate, we have only 62.5 microseconds to increment the three pointers, look up the sine values, multiply each by the amplitude, then scale and offset the three results to calculate the duty cycle values. This is a reasonably tight time frame, so this part of the firmware was written in assembly language and hand-optimised for speed.

But by how much should we increment the look-up table pointers? If we incremented the pointers by one each 62.5 microseconds, one cycle would take 62.5µs x 512 = 32ms, giving 31.25Hz. Clearly we must somehow increment the pointers by a fractional amount, ranging from nearly zero to 2.4, with a few digits resolution.

The solution was to create a 32-bit accumulator for each pointer, and to use bits 17 through 25 as the 9-bit pointer into the table. Now incrementing the accumulator at 62.5µs would produce an output frequency of 0.000238Hz! So for 1Hz output, we increment the accumulators by roughly 4200 and for 50Hz, about 210,000. We don't need this kind of frequency range or resolution, so the firmware limits the range from 0.5 to 50Hz (or 75Hz) and the resolution to 0.05Hz.

The control routine of the firmware is a fairly straightforward state machine that controls the frequency and voltage set points for the PWM generation part, according to the state of the various inputs.

Next month we will provide full details of the construction, testing and installation. SC



SoftStarter – tames

Are you alarmed by the juicy "splattt" from your mains power point when you plug in something like a large plasma TV set? Do you sometimes burn out light and power point switches because of the surge currents at switch-on? Or perhaps you occasionally trip circuit breakers because of appliance switch-on surge currents. This is a very common problem but there is a simple cure: our SoftStarter. It tames those nasty surge currents while having no effect on appliance performance.

By NICHOLAS VINEN

This project was triggered by a number of readers experiencing problems with switch-on surge currents.

The first was a school teacher who wanted to switch on banks of laptop computers in a language laboratory. Each time he attempted to do so it would trip out the mains circuit breakers. The breakers would trip out even though the total power drain of the laptops was far less than the breaker's rated current.

Eventually he found that the only way to switch on without tripping the breakers was to switch on the laptops in groups of three or four.

The second instance was a reader who fitted a large number of 10W compact fluorescent lamps to a large chandelier – he was trying to toe the government line by not using those nasty (but attractive candle style) incandescent lamps. He found that each time he switched on the chandelier, it tripped the 10A breaker.

We have a similar problem in the SILICON CHIP offices with computer workstations comprising two monitors and a desktop PC. Each combination has around 1.15µF of capacitance at the mains plug and it can draw in well excess of 100A when switched on!

Worse, one of our staff members measured the input capacitance of his current model Panasonic 50-inch plasma TV at 1.3µF, between Active & Neutral (with its mains switch off). Add in the capacitance of a DVD player and VCR used to feed the Plasma set and you can start to see there is a major problem.

All of the above problems relate to appliances which have switch-mode power supplies. In essence, these look and behave like a large capacitor being switched across the 230VAC mains supply. No wonder you get a big splat from the power switch.

Fig.1 shows the essentials of a switch-mode power supply. There is typically a 470nF capacitor connected directly between the Active and Neutral leads followed by a bridge rectifier feeding a 470µF 400V electrolytic capacitor to develop around 325V before the switch-mode circuitry itself. No wonder these circuits generate such big surge currents.

We did a simulation of this circuit to get a handle on how big these currents can be. Fig.2 tells the story. Depending on the moment of actual switch-on, the peak current can easily be more than 200A and this is backed up by some scope measurements which tell the same story.

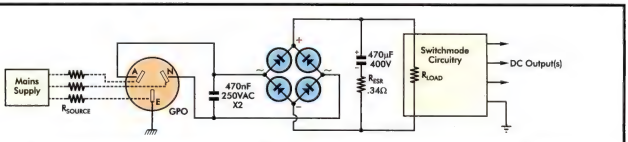
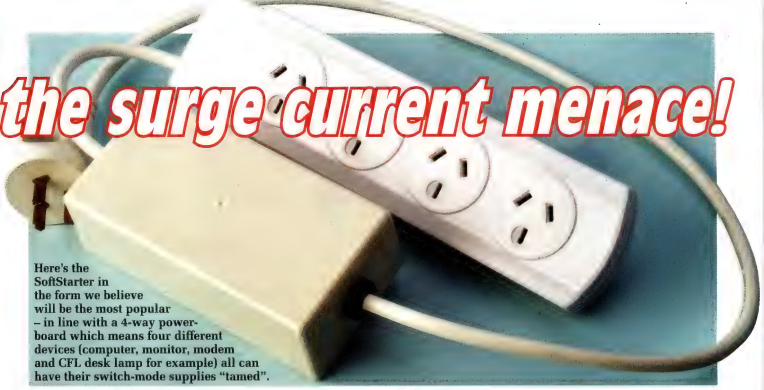


Fig.1: the configuration of a typical switch-mode power supply. An X2 capacitor (typically 100-470nF) is connected between Active and Neutral to reduce the amount of switching noise that couples from the switching circuitry back into the mains leads. The 230VAC is then rectified and filtered to produce around 325V DC and this is converted to lower regulated DC voltages by the switch-mode module. Also shown is typical capacitor bank ESR (equivalent series resistance) and the mains source impedance due to cabling etc, both of which affect the unit's peak current draw at start-up.

the surge current menace!



Here's the SoftStarter in the form we believe will be the most popular – in line with a 4-way power-board which means four different devices (computer, monitor, modem and CFL desk lamp for example) all can have their switch-mode supplies "tamed".

Note that some switch-mode power supplies have active power factor correction (active PFC) which involves extra circuitry. This reduces the in-rush current but there is still an initial surge as the storage capacitor(s) charge.

And while no switch-mode circuitry is involved, a similar surge current problem can occur when large transformers are followed by bridge rectifiers and large capacitors.

Think about the reader who built a very large power amplifier with a 1kVA toroid power transformer. Switching it on could also trip a circuit breaker or cause the room lights to momentarily flicker.

The SoftStarter solution

We actually tried several different approaches before coming up with the SoftStarter. Perhaps the simplest and most obvious approach is just to wire a high current NTC (negative temperature coefficient) thermistor in series with the 230VAC mains supply, eg, inside a power board.

WARNING!

This Soft Start circuit is powered directly from the 230VAC mains and operates at lethal voltages. DO NOT TOUCH ANY PART OF THE CIRCUIT WHILE IT IS PLUGGED INTO A MAINS OUTLET OR CONNECTED TO MAINS WIRING and do not operate the circuit outside its plastic case or without the lid screwed onto the case.

These devices initially have a fairly high resistance which drops quickly as they heat up. The high initial resistance limits the in-rush current and after a shortt period, this drops enough to allow normal current to flow into the load after the initial surge.

The problem is that they run really hot – up to 228°C or higher! This is unavoidable since they rely on the heat to

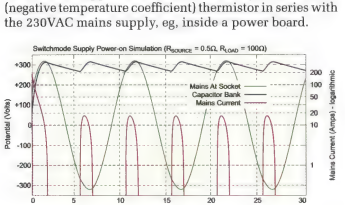


Fig.2: SPICE simulation of Fig.1. Mains source impedances are set to 0.5Ω and the load resistance is 100Ω. Inrush current peaks at over 200A, limited by the mains source impedance, bridge rectifier impedance and capacitor bank ESR. The capacitor bank charges almost completely in the first half-cycle. The high current distorts the mains waveform both during the initial in-rush and at the voltage peaks where some "flat-topping" is visible.

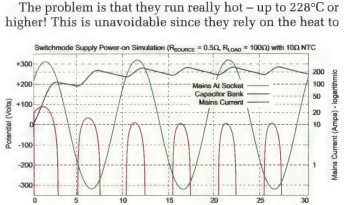


Fig.3: SPICE simulation with the same circuit as shown in Fig.1 but with a 10Ω 15A NTC thermistor connected in series between the mains socket and suppression capacitor/bridge rectifier. The capacitor bank charges more slowly, over several cycles and peak current is reduced to around 30A (close to our measurements). Note how the bridge conducts for a longer period, even after the capacitor bank has charged.

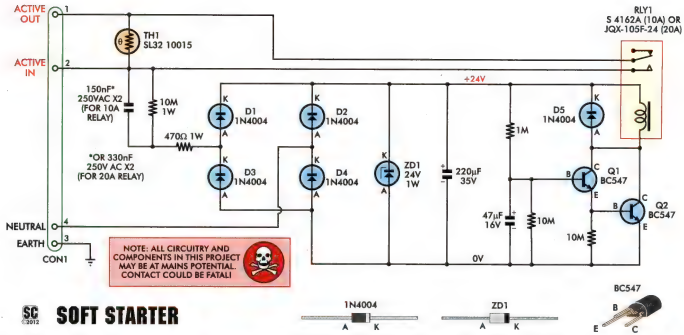


Fig.4: the complete circuit diagram of the SoftStarter. NTC thermistor TH1 limits inrush current and after about two seconds, it is shorted out by relay RLY1 for minimal heat generation and power loss. NPN transistors Q1 & Q2 drive the relay coil and their switch-on is delayed by the 47µF capacitor. The +24V rail is derived from mains using an X2 series capacitor, bridge rectifier and zener diode.

lower their resistance and allow enough current to flow.

Plainly, they run too hot to be installed inside a plastic power board; they would melt the plastic! Apart from that, it's a waste of power. Depending on the load current, dissipation could be in excess of 5W.

Our solution is simple – we use a relay to short out the thermistor after a few seconds. The voltage drop across the relay is very low and so there's virtually no power loss apart from that required to keep the relay energised. In the case of our SoftStarter, this is less than half a watt.

The proof that it works is in Fig.6. This shows the same computer set-up as in Fig.5 being switched on with the SoftStarter connected in series. The inrush current is now limited to around 25A.

Note that the current waveform is much smoother and lacks the big initial spike. Note also that the power supply capacitors charge over many more mains cycles than they would without the SoftStarter connected.

A number of scope screen grabs in this article reinforce the story: without the SoftStarter you get big in-rush currents and splats from the power switch. Those splats, by the way, are not just annoying: each one is responsible for just a little more of the switch contacts melting and wearing away.

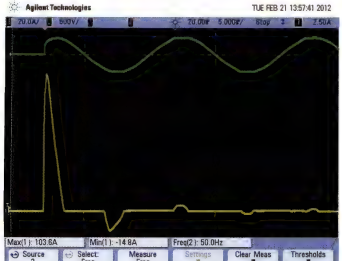


Fig.5: current for a computer workstation over the first few mains cycles after power is applied The initial draw of 103.6A is due to the initial charging of the capacitor banks in the switchmode supplies. The second half-cycle peak is much lower.

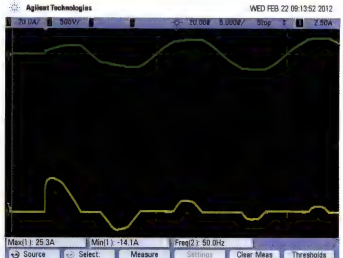
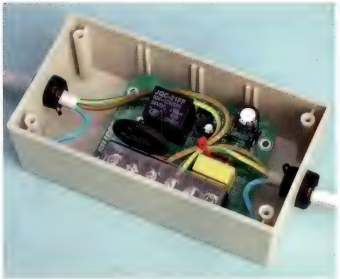


Fig.6: the same situation as Fig.5 but with the SoftStarter in use. Maximum current draw is much lower at 25.3A for the first half-cycle and 14.1A for the second. The capacitor banks charge more gradually, over five full mains cycles or so (100ms).



Here are the two versions of the SoftStarter – on the left the PCB is attached to the base of a standard electrical junction box (in this case an Arlec 9071 but it could be a Clipsal, HPM etc). This version has the 20A relay but again, it could be the 10A relay. On the right is the same board (with 10A relay) placed inside a standard UB3 Jiffy box, as shown in the photo at the start of this article.

With the SoftStarter everything is sweetness and light and there is no drama at switch-on.

Two versions

The SoftStarter can be built in two different ways. First, its PCB can be housed inside a UB3 jiffy box in-line with a standard power board, extension lead or equipment mains lead. It also fits into a standard electrical junction box so that it can be permanently wired into, say, a lighting circuit. It can handle loads of up to 10A or 2300W. That's the maximum load rating of a typical residential power point (or GPO – which stands for General Purpose Outlet).

Circuit description

Refer now to Fig.4, the complete circuit diagram. Incoming mains power is wired to the ACTIVE IN and NEUTRAL terminals while the load is connected to the ACTIVE OUT and NEUTRAL terminals.

NTC thermistor TH1 is permanently connected between the incoming Active line and the load.

This is an SL32 10015 thermistor has a nominal resistance at 25°C of 10Ω, falling to 0.048Ω at 228°C, which is its sustained body operating temperature with a load current of 15A. That is its rated maximum steady state current and it takes around four minutes to reach operating temperature under full load conditions.

In our application, this will never happen as it's shorted out after about two seconds by the contacts of relay RLY1.

NTC thermistors have a few advantages over power resistors in this role.

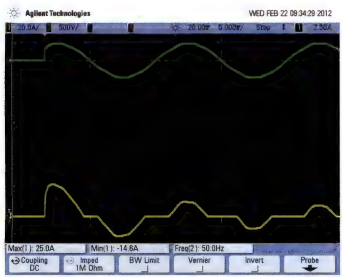


Fig.7: current flow for a 300VA toroidal transformer charging a large capacitor bank through a bridge rectifier, at switch-on. Peak current draw is 24A on the first cycle and 14A on the second. It could be much higher with a larger transformer.

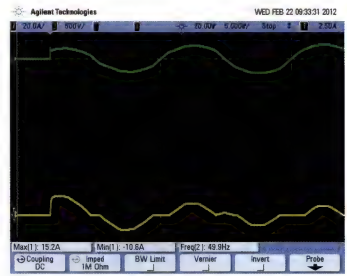


Fig.8: the toroidal transformer based power supply, this time with the SoftStarter connected up. The inrush is much lower with a peak of 14A on the first cycle and 11A on the second. Current is drawn over a larger portion of the mains cycle.

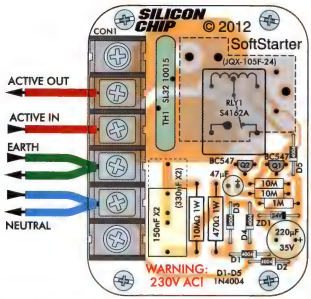


Fig.9 the component overlay for the SoftStarter with a straight-on shot of the PCB at right for comparison. Take care with the mains wiring and NEVER operate the SoftStarter with the lid off the case – it bites!

Firstly, they are rated to handle the very high (~250W) initial dissipation. Secondly, their natural drop in resistance as they heat up provides a gradual increase in current.

Finally, they are much more compact than a typical power resistor of equivalent current rating.

There are no timer ICs or oscillators in this circuit. Instead, the relay time delay of two seconds is provided by the low-pass filter formed by the 1MΩ resistor and 47µF capacitor, in combination with the base-emitter voltages of NPN transistors Q1 & Q2.

At switch-on, the 220µF capacitor is initially charged to 24V and the 47µF capacitor starts out discharged. After a couple of seconds, when the charge across the 47µF capacitor reaches about 1.5V, the Darlington formed by NPN transistors Q1 and Q2 turns on and energises the relay. Its contacts short out the NTC thermistor, applying the full 230VAC to whatever is being switched.

After that, the full load current passes through the relay until such time as incoming mains power is switched off. After a second or so, the 220µF capacitor discharges and the relay switches off. Diode D5 protects Q1 & Q2 from the resulting inductive voltage spike.

After switch-off, the 47µF capacitor discharges via its parallel 10MΩ resistor (also via Q1's base-emitter junction and the 1MΩ resistor). After about 30 seconds it's sufficiently discharged for the unit to be switched back on again with close to the normal two-second delay.

If it's switched back on earlier, the delay will be shorter but should still be sufficient.

Power supply

The 24V rail is derived from the 230VAC mains using a capacitor/zener regulated supply. Diodes D1-D4 form a bridge rectifier feeding the 220µF filter capacitor and 24V zener diode ZD1 limits the voltage across this capacitor to around 24V.

If we simply connected the full 230VAC mains to the input of the rectifier, it and the zener diode would burn out in spectacular fashion due to the virtually unlimited current flow.

This is similar to the problem we are trying to avoid with the SoftStarter! We need limit this current to a safe level.

The obvious way to do this is to use a resistor but then that resistor would have about 200V across it and its dissipation would be high, making the circuit very inefficient. So instead of using resistance we use the reactance of a capacitor to limit the current. We simply choose one with an impedance of around 20kΩ at 50Hz.

The formula for capacitor impedance is:

$$\frac{1}{(2\,\pi\,f\,C)}$$

so for a 150nF capacitor at 50Hz we get 21.2kΩ. This gives a much higher efficiency; over 50%.

This process is illustrated in Fig.6, the output of SPICE simulation of the power supply circuit (using a 220nF capacitor but the principle is the same).

The dashed green trace shows the voltage across the X2 capacitor and the difference between it and the mains voltage waveform (red trace) is the voltage across the rectifier, which is limited to around ±25V due to the zener diode.

The dashed mauve trace shows the current flowing through this X2 capacitor while the dotted blue trace shows

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[HDDVR]

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The Driver has a on-board rectifier so polarity is not important.

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2 lamps wired in series with our 24V PSU.
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Parts List – SoftStarter

1 PCB, code 10104121, 58 x 76mm
(available from Silicon Chip for $10 + P&P)
1 6-position, 4-way PCB-mount terminal barrier (CON1)
(Jaycar HM3162, Altronics P2103)
2 M3 x 15mm machine screws with flat washers, star washers and nuts
1 Ametherm SL32 10015 NTC thermistor
(Element14 1653459)
1 10A 24VDC coil SPDT relay
(Altronics S4162A or equivalent) **or**
1 JQX-105F-24 20A SPDT relay, 24V DC coil
(Futurlec JQX-105F-24 or equivalent)
1 UB3 jiffy box or mains junction box *(eg Arlec 9071)*

Semiconductors
2 BC547 100mA NPN transistors (Q1, Q2)
1 24V 1W zener diode (ZD1)
5 1N4004 1A diodes (D1-D5)

Capacitors
1 220µF 35V/50V electrolytic
1 47µF 16V electrolytic
1 150nF X2* (Element14 1215452) (for 10A relay) **or**
1 330nF X2* (Element14 1200831) (for 20A relay)
(X2 capacitors will have their value printed on them)*

Resistors (0.25W, 5%)
1 10MΩ 1W *(code: brown black blue gold)*
2 10MΩ *(code: brown black blue gold)*
1 1MΩ *(code: brown black green gold)*
1 470Ω 1W *(code: yellow violet brown gold)*

Additional parts for Jiffy box version
2 cord-grip grommets to suit 7.4-8.2mm cable
(Jaycar HP0716, Altronics H4270)
1 short length 2.5mm diameter heatshrink tubing
1 power board
1 small cable tie

Additional parts for junction box version:
4 No.4 x 9mm self-tapping screws

the product of this current with the mains voltage, ie, the instantaneous power.

This power figure is positive when the current and voltage are in phase and this represents power drawn from the mains while when it is negative, the current and voltage are out of phase and it represents current flowing back into mains.

As you can see, power tends to be drawn from the mains when the X2 capacitor is charging, ie, when the voltage across it is increasing in absolute terms. It is returned to the mains when this capacitor is discharging. There is also the additional current flow which is that consumed by the circuit being driven which is on top of the capacitor charge/discharge currents.

The actual power consumed is the difference between that flowing into and out of the circuit. As you can see from the figure, the area under the curve representing the power drawn from mains is slightly larger than that returned and the simulation gives the difference in this case as 421mW. This is the real power drawn by the circuit.

A straight-on pic of the alternative mounting, the mains junction box. This is actually on the baseplate; the box fits over the top when the baseplate is mounted (eg, to a joist).

The apparent power is calculated by multiplying the RMS current by the RMS voltage (ie, 230V). The RMS current is 15.6mA; therefore the apparent power is 3.59VA. This gives a power factor of 0.421 / 3.59 = 0.12. This may seem low but given how little actual power the circuit draws, it isn't a problem.

If we re-run the calculations using a 150nF capacitor, we get a real power of 210mW, an RMS current of 10.7mA, an apparent power of 2.46W and a power factor of 0.085. This agrees almost exactly with our measurements.

The 10MΩ resistor has negligible effect on the operation of the circuit and simply serves to discharge the X2 capacitor once the unit is unplugged (so you won't get a shock if you open up the box). The 470Ω resistor limits the inrush current when the X2 capacitor is initially charged to a maximum of 0.5A. Both of these resistors are 1W types since these are generally rated for use with mains voltages.

An important aspect to note is that while 24V zener diode ZD1 limits the voltage across the filter capacitor (220µF) to 24V initially, once the relay is actually energised, the voltage will drop to around 15-16V and ZD1 no longer conducts.

The reason for this is that the voltage divider formed by the reactance of the X2 capacitor, the 470Ω series resistor and the relay coil resistance (around 1600Ω) limits the filter capacitor voltage to around 15.8V. This is enough to keep the relay reliably energised but reduces the power consumption of the circuit.

Relay & X2 capacitors

One of two specified relays can be used: one is rated

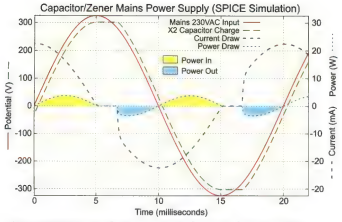


Fig.10: SPICE simulation output showing how the X2 capacitor/zener power supply works. The X2 capacitor charges and discharges with each mains half-cycle, dropping the 325V DC peak voltage from mains to 24V. The extra energy from the higher voltage is stored in the capacitor and returned to the grid later in the half-cycle.

to switch 10A – it can be an Altronics S4162A or JQC-21FF-024. The other is physically larger and is rated at 20A (7200VA) and has type number JQX-105F-24.

We have specified a 150nF X2 capacitor for use with the 10A-rated relay and a 330nF X2 capacitor for the 20A-rated relay because its coil resistance is lower, at 660Ω.

Construction

The SoftStarter is built on a 58 x 76mm PCB, coded 10104121. It is double-sided with plated through-holes, so the top layer can carry some of the load current.

Start by fitting the three smaller resistors. Use the colour code table or a DMM to check their values. Follow with the five standard diodes and the zener diode, orientated as shown on the overlay diagram (Fig.9). All diodes have their cathode stripes facing either the right side or bottom of the PCB. You can then fit the two 1W resistors, again using referring to the colour codes table or a DMM.

Crank the leads of the two BC547 transistors to suit the PCB mounting holes, using small pliers, then solder them in place. Follow with the small and then larger electrolytic capacitors. In both cases, the longer positive lead goes in towards the right side of the board.

The X2 capacitor and relay go in next. Use 150nF for the 10A relay or a 330nF for the 20A relay. You may need to turn up your soldering iron temperature to solder the relay as it connects to a large copper area. Then fit the thermistor, making sure it is pushed down as far as it will go before soldering its leads. It will also need a hot iron.

Attach the terminal barrier using two M3 x 15mm machine screws. Place flat washers under the heads and star washers between the nuts and PCB, then tighten them down. Check the terminal barrier is parallel to the edge of the PCB and then solder its pins, again with a hot iron.

Housing

As already noted, the SoftStarter PCB can be installed in either a UB3 jiffy box in-line with a standard 4-way 230VAC power board or extension cord, or in a standard junction box if the device is to be permanently wired into a circuit. We will deal with installation in a UB3 jiffy box first.

Originally we designed the PCB to snap into the moulded side rails of the UB3 box but the thermistor is quite tall and interfered with the lid, so we have made the final board narrower and it simply sits in the bottom of the case. It can be glued in place after it has been wired up and tested, so it can't move and put stress on the wiring.

Start by drilling a hole centred in each end of the box, 4-5mm at first, then enlarge them to 14mm using a tapered reamer or stepped drill bit. It's better to make the holes slightly too small and enlarge them later if necessary since if they are too big, the cord-grip grommets will be loose and you will have to get a new box and start again.

The holes can then be elongated with a file in one direction, making a 14 x 15.9mm opening (flat sides, rounded ends), to prevent the grommets from rotating. The correct profile is shown on page 244 of the Altronics 2011-2012 catalog (Type B).

Now cut the power board cord. We cut ours about 23cm from the power board so that the SoftStarter unit sits close to the board. Strip 75mm of the outer insulation, then expose 7mm of copper from the Active and Neutral and Earth wires. At the other (plug) end, strip 130mm of the

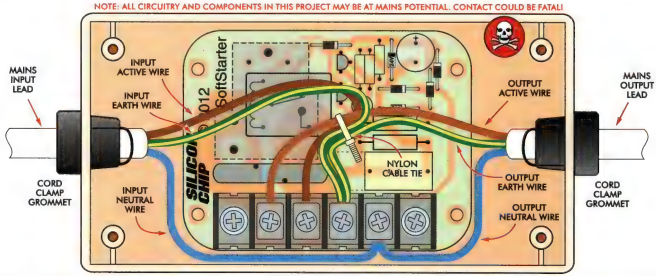


Fig.11: here's how to wire it inside the UB3 Jiffy box. We placed it in line with a standard 4-way powerboard – at about $2.50 each they're the cheapest way to get a mains plug, cord and (four!) sockets.

outer insulation, then the inner wires the same as before.

Place one of the cables inside a cord-grip grommet, with the narrower part towards the exposed wires and a small amount of the outer insulation protruding beyond the grommet. If you're lucky enough to have a grommet insertion tool you can use that but otherwise, squeeze it together hard with a large pair of pliers and then push it into one of the holes in the jiffy box. This requires quite a bit of brute force and co-ordination but if you do it right, the grommet will go in and it won't be possible to pull it out.

If it won't fit, enlarge the hole slightly and try again. **Give the cords a firm tug to check they are anchored properly – you must not be able to pull them out or move them.**

Now twist the exposed strands of the Active and Neutral wires and screw them into the appropriate locations on the terminal barrier. Refer to the wiring diagram of Fig.11. The two Neutral wires go into the location marked "N" and should be twisted together.

The Active wire from the power board goes to the terminal at the opposite end ("ACTIVE OUT") while the Active wire from the plug goes next to that ("ACTIVE IN"). Twist the two earth wires together tightly and attach them to the terminal marked E. **In each case, ensure that the screw is done up tightly and that there are no exposed or stray copper strands.**

You can then place cable ties to hold the Active and Earth wiring in place (see photo). Secure the PCB into the bottom of the box using hot melt glue or silicone sealant and fit the lid.

Junction box

We also designed the board to fit in an Arlec 9071 junction box (other brands such as Clipsal and HPM are very similar). The PCB's four mounting holes line up with those in the base of the junction box and the rounded corners leave enough room to access the other mounting holes, so you can screw it to a ceiling joist or whatever.

The 230VAC mains wires can enter the box lid from the side, using one or two of the knock-out sections. Note that if it is to be installed in permanent wiring, the task should be done by a licensed electrician or suitably qualified person.

Check the wiring

Going back to the version in a UB3 Jiffy box, before powering up, it's a good idea to do some basic tests. Measure the resistance between the incoming and outgoing Active wires – it should be close to 10Ω which is the cold resistance of the NTC thermistor. If it is much lower than this, you may have a short circuit somewhere.

Also check the resistance between each Active line and the Neutral line. The reading should be around 15MΩ. Again, if it is low, check carefully for shorts.

Finally, check for continuity (ie, 0Ω) between the Earths of the in-going and out-going power cord. Then apply power (it isn't necessary to attach a load). After about two seconds you should hear the click as the relay turns on. Remove power and the relay will click again within a second or so, as it releases.

Assuming all is well, repeat the test with a load and this should confirm that it is working properly. For best results, once you have switched off power to the SoftStarter, wait at least 30 seconds before turning it back on. SC

Why is the 50Hz AC

Everyone knows that the 50Hz AC mains waveform is a sinewave, right?

Well, in theory it is a sinewave but in practice it is distorted because the peaks have been clipped off. For years now our scope screen grabs have shown this but we have not dwelled on the reasons why.

Recently though, we have had emails from readers who have sent photos of their scope screens showing the classic flat-topping of the mains waveform. And they want to know why this is happening.

You can blame this gross distortion of the mains waveform on two factors: gas discharge lighting and switch-mode power supplies.

Gas discharge lighting refers to all lighting systems which use an electric current through a gas to generate light. It applies to all high and low-pressure sodium lamps, mercury vapour lamps and fluorescent lights.

In each of these cases, the gas discharge draws current from the AC mains supply only when the actual voltage across the lamp exceeds about 100V. So the current is only drawn from the peaks of the waveform and this inevitably loads down or clips off the peaks.

In recent years the situation has become much worse for the electricity generators and distributors with the widespread use of switch-mode power supplies in virtually all electronic appliances.

It more or less started with the advent of PCs and their adoption of the more efficient switch-mode rather than conventional mains transformer-driven power supplies which are much heavier, bulkier and more expensive.

Switch-mode power supplies were naturally also used in laptop supplies, then TV sets, DVD players etc. Now they are used in virtually all electronic equipment with the sole exception of high performance audio amplifiers (such as our own Ultra-LD amplifier series).

Naturally all those large power-hungry Plasma TVs (albeit these days not quite so power-hungry) and large screen LCD TV sets use switch-mode supplies.

The reason why switch-mode power supplies are such a problem is that they all essentially consist of a bridge rectifier and a big capacitor, followed by the switch-mode circuitry itself. It is the bridge rectifier and big capacitor which is the problem because current only flows into the capacitor at the peaks of the 50Hz mains sinewave.

All of the power drawn by the appliance is drawn from the mains during the peaks of the waveform – not at the other times (unless they are fitted with active power factor correction and relatively few are).

Have a look at the simulation of Fig.2 on the second page of the SoftStarter article. This set of curves depicts what happens: large pulse currents which coincide with the peaks of the mains waveform.

The simulation is for a 100Ω load which will draw a nominal 529 watts from 230VAC mains. But the current drawn from the mains is not a nice sinusoidal 2.3A but is a pulse waveform with peaks of about 15A!

No wonder the peaks of the waveform are being clipped off.

mains waveform distorted?

By LEO SIMPSON

To make the problem even worse, large appliances such as washing machines and inverter-driven air-conditioners also have large capacitor-input power supplies, ie, the same as the front-end of switch-mode power supplies.

It's not just domestic power loads which are causing the mains distortion. It is just as bad in industry which is a big user of gas discharge lighting.

As well, consider those large AC drives used in industry which consist of 3-phase induction motors with variable frequency, variable voltage drives (think of them as big inverters). Also now widespread in industry are use single-phase and 3-phase inverter-driven welders.

Yep, they use large capacitor-input power supplies.

You can see a low-power (if 1.5kW can be called low power!) variable speed drive circuit in our article on the Induction Motor Speed Control described elsewhere in this issue.

And remember those high-performance audio amplifiers which don't have switch-mode power supplies? They still use a capacitor-input power supply following the large and heavy mains transformer – so they are just as bad as switch-mode power supplies in drawing large peak currents from the peaks of the mains waveform.

Finally, let us not forget compact fluorescent lamps (CFLs). Every one of those has a switch-mode power supply to the drive the fluorescent tube.

12V halogen down-lights are another offender; these days they are driven by so-called "electronic" transformers which – you guessed it – are another form of switch-mode power supply.

And of course there are the even tinier switch-mode plugpacks we use to charge our mobile phones, iPods, iPads, MP3 players etc.

What a nightmare!

By comparison with all of these, the much-maligned incandescent lamp is a relatively benign resistive load!

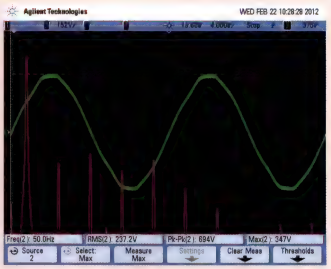
Distortion analysis

To demonstrate the degree of the problem, have a look at the scope screen grab above. This shows a typical 50Hz mains waveform (green trace) as measured in the SILICON CHIP premises.

Not only can you see the characteristic flat-topping but the slopes of the sinewave also show some ripples, a further artefact of the nasty loads imposed by all gas discharge lights and capacitor-input power supplies.

Just to make it more interesting, we decided to do an FFT analysis of the distorted waveform. This shows harmonics of the 50Hz waveform out to the 19th, ie, to 950Hz. These are depicted as the purple spikes. The FFT (Fast Fourier Transform – essentially a frequency spectrum) shows that the harmonics are predominantly odd, eg, 3rd, 5th, 7th, 9th, 11th and so on, corresponding to 150Hz, 250Hz, 350Hz, 450Hz, 550Hz etc.

We also calculated harmonic distortion of the waveform based on the FFT and the result was 2%. If that was an audio amplifier, we would reject it. Unfortunately, the electricity distributors and consumers cannot.



This screen grab shows the typical flat-topping of the 50Hz AC mains waveform (green trace) caused by the peak currents drawn by gas discharge lighting and switch-mode power supplies. The purple spikes show the relative amplitudes of the 50Hz fundamental and the odd harmonics up to 550Hz. In fact, the harmonics are significant up to at least the 19th, 950Hz.

As an aside, notice that the on-screen measurements show that the mains waveform has an RMS value of 237.2V and a peak-to-peak value of 694V (or 347V peak).

If that flat-topping was not present and the mains waveform was a pure sinewave, the peak-to-peak value would only be 670.8V (335V peak). So in effect, the electricity generators are having to deliver a larger peak to peak waveform in order that the customer gets an RMS voltage within the normal range.

And if that flat-topping, with its higher peak power on the waveform crests did not occur, the power losses in the entire electricity grid would be less, by at least a few percent.

Think about that next time you switch on any piece of electronic equipment or flick a switch to light a room with fluorescents, CFL or otherwise.

We should conclude with a note about "dirty power". This is a buzz word used by those purveyors of power factor correction doodads which supposedly "clean up" the mains waveform. They don't work. SC

Just one of the so-called "power saver" boxes we've looked at over the years. They are supposed to work by cleaning up your "dirty" power waveform. Only one minor problem with these devices: they don't work!

Get a million resistance values with this . . .

6-Decade Resistance Substitution Box

By JIM ROWE

One of the most common tasks when trying out a new circuit is fine-tuning the resistance values. This task is made a lot faster, easier and more precise by this 6-decade resistance substitution box. It's easy to build and gives you the ability to select from thousands of different resistor values between 10Ω and 10MΩ, just by twiddling the switches. When you have found the optimum, just read off the value on the switches.

YES, WE KNOW about those little "resistor substitution wheel" gadgets, which you can pick up for around $25. Generally they offer a selection of 36 different resistor values, covering a very wide range, usually between 5Ω and 1MΩ. They're OK but you will usually find that the value you need is not present in that limited range of only 36 values.

Then you dive into your resistor stock and hope that you can find a value that will work. We've all been there and know how frustrating it is to find that Murphy's Law is applicable – there are none left in the drawer concerned. In any case, you tend to end up with a motley collection of resistors on the bench, all of which have to be put back in their drawers afterwards. That's so boring.

Resistor substitution wheels have another drawback which is that their internal resistors are usually only 5% tolerance. So even if one of the 36 nominal values turns out to be suitable for the circuit you're working on, you still need to check the actual value with your DMM before making your final selection of the value to be used.

So what we really need is more like an old-fashioned "decade resistance box", with a much larger selection

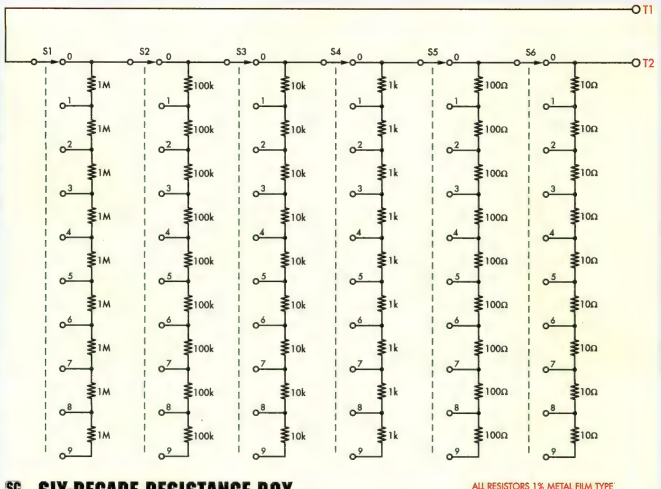


Fig.1: the circuit consists of six 10-position rotary switches (S1-S6) in series with terminals T1 & T2. The associated resistor strings allow each switch to select a unique resistance value ranging from 0-9MΩ (S1) down to 0-90Ω (S6)

of closer-tolerance resistance values. But those old decade boxes were big, clunky and expensive. Even the latest models are quite expensive.

So why not build your own? We have produced a compact 6-decade resistance box using readily available rotary switches and 1% metal film resistors, all mounted on a PCB to make assembly a cinch.

A million resistance values

This unit allows you to dial up a million resistance values between 10Ω and 10MΩ, selectable in 10Ω increments. It uses only 54 resistors, so if you use standard 1% metal film resistors they'll cost you less than $3.50.

Add in the cost of a UB1 jiffy box, six standard rotary switches and knobs, a pair of binding post terminals and a PCB and it is still not a large amount – a small fraction of the cost of a commercial decade box, in fact.

For even higher accuracy, you can use 0.1% metal film resistors instead of the 1% types. These will bump up the total cost to over $100 but it will still be much less than the price of a comparable commercial unit.

How it works

Fig.1 shows the circuit. Six 10-position switches S1-S6 are wired in series, between the two binding post terminals T1 and T2. The resistors are connected in daisy-chain fashion around the six switches. Each click of switch S1 increases the total resistance by 1MΩ, while each click of switch S6 increments it by 10Ω.

Since all six switches are connected in series, you can dial up any resistance between 0Ω (all switches set to "0') and 9.99999MΩ (all switches set to "9'), in increments of 10Ω.

Mind you, while we said that you can select a million different resistance values, in practice you would not use all six switches to select each resistance; it's pointless. It all comes down to the tolerance of the resistors you are using. Even if all 54 resistors are 0.1% tolerance, you will quickly come to realise that if you use three consecutive decade switches to select a value, the 3-digit resolution of the selected value is already equal to the tolerance of ±0.1%.

You also need to consider that the minimum resistance of the box with all switches set to "0" is not exactly 0Ω. That's because the contact resistance of the switches and the resistance of the PCB tracks does introduce a small amount of residual resistance – typically around 0.25Ω, or 250 milliohms. In practice, this doesn't matter much and merely increases the error of the

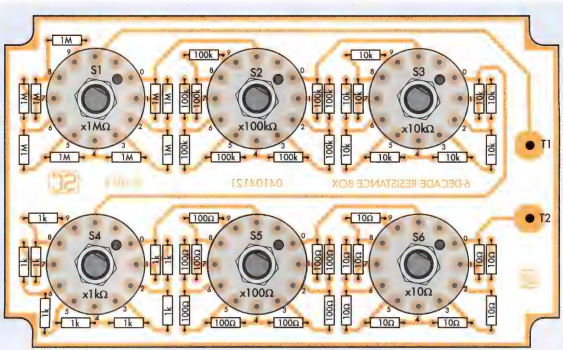


Fig.2: follow this parts layout diagram to build the 6-Decade Resistance Box. Note that the switches must be installed with their anti-rotation spigots orientated as shown. The tops of these spigots must also be removed using side cutters.

two lowest settings of S1 (10Ω and 20Ω) beyond the basic ±1% of all other ranges: about +3% for the 10Ω setting and +1.5% for the 20Ω setting.

We will discuss some of these points later. For now though, this 6-decade resistance substitution box is a very useful electronics accessory and it is dead-easy to build.

Construction

All of the switches and resistors are on the PCB which mounts inside a standard UB1 jiffy box. The complete PCB assembly is attached to the box lid, being held there by the mounting nuts of the six switches.

The two binding posts are the only components not on the PCB; they are mounted on the lid itself, with their rear connection spigots connecting to the two large pads on the PCB when the latter is attached to the lid.

The PCB is single-sided but we strongly recommend that you use a fibreglass PCB which has a solder mask. This will reduce the possibility of leakage paths developing in the future which could reduce the accuracy on the top resistance range.

The component overlay is shown in Fig.2. Fit the resistors first. There are only six different values: 10Ω, 100Ω, 1kΩ, 10kΩ, 100kΩ and 1MΩ, with nine of each, making 54 in total. Each value is clustered around its respective switch. Don't mix up the values.

Before fitting the rotary switches, cut the spindle of each switch to about 10mm long or just enough to suit the control knobs you are using. Make sure you remove any burrs from the top end of the spindles with a file, so that their knobs will slip on easily later.

All six switches are mounted on the board with the orientation shown in Fig.2. As you can see, the moulded locating spigot on the front of each switch body is at "1:30", while each switch's rotor connection pin (not visible in Fig.2 or Fig.3) is in the "3:00" position as viewed from the top.

Once all six switches have been fitted to the board and soldered in, it's a good idea to make sure that they are all set for a span of 10 positions. To do this, turn the switch spindle fully anticlockwise and then remove its mounting nut, star lockwasher and "stop washer'. Then replace the stop washer with its stop pin passing down through the hole between the numbers "10" and "11" moulded into the switch body.

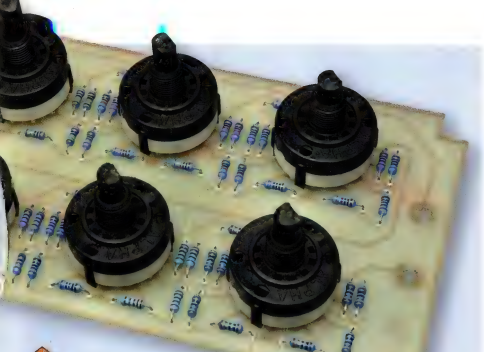
Replace the lockwasher and mounting nut. Then try turning the switch spindle clockwise by hand and you should find that it can be moved through a total of 10 positions (0-9 inclusive).

You will also need to use a pair of side cutters to nip the plastic spigot off all the switches. If this is not done, the spigots stop the switches from mounting flush underneath the lid. Do this for all six switches.

It is also a good idea to use an old toothbrush and some methylated spirits to scrub off all solder flux residue from the underside of the PCB. This will remove any leakage paths which will otherwise reduce the accuracy of the values selected when you are using

Table 1: Element14 0.1% Resistors

1083036	10Ω metal film resistor	0.1% 0.25W	$18.60 (2 packs)
1751317	100Ω metal film resistor	0.1% 0.25W	$15.00 (2 packs)
1751444	1kΩ metal film resistor	0.1% 0.25W	$15.00 (2 packs)
1751550	10kΩ metal film resistor	0.1% 0.25W	$15.00 (2 packs)
1751658	100kΩ metal film resistor	0.1% 0.25W	$14.20 (2 packs)
1751718	1MΩ metal film resistor	0.1% 0.25W	$16.50 (2 packs)



This is the completed unit before it is mounted on the lid of the case.

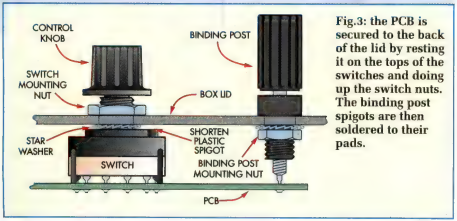


Fig.3: the PCB is secured to the back of the lid by resting it on the tops of the switches and doing up the switch nuts. The binding post spigots are then soldered to their pads.

the Megohm range switch.

The PCB assembly can now be placed aside while you prepare the box.

Preparing the box lid

There are eight holes to be drilled and reamed in the box lid. There are six 10mm-diameter holes for the threaded ferrules of the switches, plus two 9mm holes for the binding posts.

You can use the front-panel artwork as a drilling template for the lid. This can be obtained in PDF format from the downloads section of the SILICON CHIP website, photocopied and stuck to the lid.

Once the eight holes have been drilled and reamed to size, you can either make a dress front panel by laminating another copy of the artwork or you can purchase a PCB front panel from SILICON CHIP.

After this you can fit the two binding posts to the panel, using the nuts and washers supplied, as shown in the diagram of Fig.3. The lid can then be lowered down until it's resting on the lockwashers for the switches. Fit the mounting nuts to each switch ferrule and this will hold everything together. The rear spigots of the binding posts can then be soldered to the matching pads of the PCB.

That done, place the lid/PCB assembly into the box itself and fit the four small self-tapping screws supplied, then push in the small rubber bungs to cover each screw head, Finally, fit the control knobs to each switch spindle.

Higher precision?

Earlier in this article, we mentioned that 0.1% tolerance metal-film resistors can be substituted for the standard 1% tolerance types, if you want your decade box to be significantly more accurate. These higher-precision resistors are available and are physically very similar to the standard 1% type – so there is no problem making this change.

But be warned that there is a significant extra cost involved – the 0.1% resistors will cost you around $1.60 each, compared with the six cents or so for 1% resistors. A set of 60 of these resistors will cost around $95, bringing the total cost of your decade box to around $140.

However, we think that the extra cost is well worth it. It is very satisfying to dial up a resistance value with two or three switches and then confirm that it's smack on the value (or very close to it) with your DMM. It means you can dial in preferred value resistors to a prototype circuit and know that you will get very similar results when you install the same physical resistor.

Sourcing 0.1% resistors

The 0.1% resistors available from Element 14 (formerly Farnell Components) come in packs of five; you need to buy two packs of each value. Table 1 lists the values. The first number is the Element14 stock number, followed by the description and the cost.

Power rating

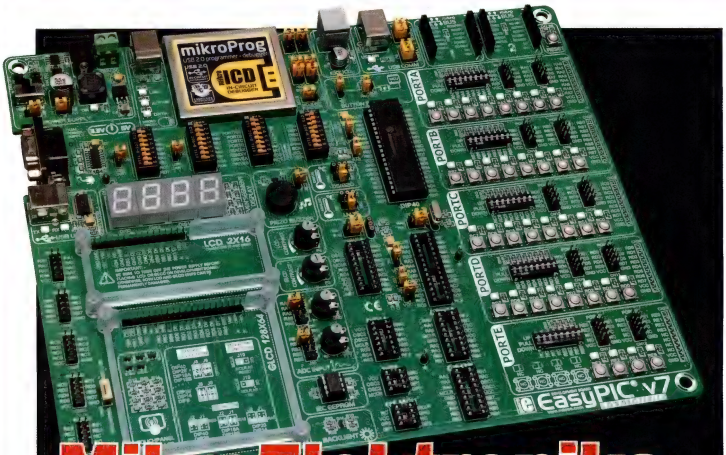
Finally, note that the power dissipation must not exceed more than 0.25W for the resistance value selected. This can be calculated using the formula $P = V^2/R$ or $P = I^2R$. SC

Parts List

1 UB1 jiffy box, 158 x 95 x 53mm
1 PCB, code 04104121, 146 x 87mm
1 dress front panel (both PCB and panel available from SILICON CHIP for $20 each + $10 P&P)
6 single pole rotary switches (S1-S6)
6 19mm diameter control knobs, grub-screw fixing
2 black binding posts
4 adhesive fixing rubber feet

Resistors (0.25W, 1% or 0.1% metal film)

9 1MΩ	9 1kΩ
9 100kΩ	9 100Ω
9 10kΩ	9 10Ω



MikroElektronika EasyPIC v7

Review by NICHOLAS VINEN

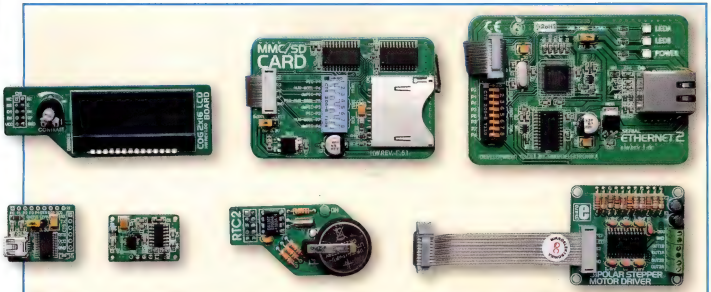
This PIC development board provides an easy way to program and debug 8-bit PIC micros. It can be used with C, Pascal and BASIC programming languages. The EasyPIC has pushbuttons, LEDs, USB ports and various other devices on-board while a variety of add-on modules such as LCDs, memory cards and network interfaces can plugged in for easy prototyping.

THIS PRODUCT is a large, solid PCB (265 x 220 x 2.5mm) populated with a variety of DIP sockets and other components including pushbuttons, headers, a power supply and a USB PIC programmer/debugger. Its purpose is to make building, programming and debugging prototype gear based around an 8-bit PIC microcontroller quick and as simple as possible.

It supports virtually all of the 8-bit PIC microcontrollers including the PIC10, PIC12, PIC16 and PIC18(F/LF/K) series. It is supplied with a 40-pin PIC18F45K22 but you can plug in whichever micro you prefer; it's just a matter of flipping a few DIP switches and swapping a couple of shorting blocks to connect the micro to your PC and begin working with it.

Besides the convenience of all the pin headers, pre-wired buttons, LEDs and ease of adding accessories, one of the great advantages of the EasyPIC is the way it ties in with MikroElektronika's other hardware and software products, including the included MikroICD in-circuit programmer/debugger (supplied) and their suite of compilers which includes C, Pascal and BASIC. The compiler, debugger and programmer all work together in an integrated development environment (IDE).

There are a large variety of accessory boards available too. It has a number of on-board peripherals, including RS-



This photo shows some of the many accessory boards which can be plugged into the EasyPIC v7. Clockwise from top left are a 16x2 alphanumeric LCD, MMC/SD memory card board, Ethernet interface board, stepper motor driver, real-time clock, 3-axis accelerometer and a USB-to-serial converter board. Three are connected to the EasyPIC via short ribbon cables while the rest plug straight into one of the on-board headers.

232 and USB UARTs (universal asynchronous receiver/transmitter), an I2C EEPROM, a 4-digit 7-segment LED display and piezo buzzer. But there is also provision for alphanumeric and graphic LCDs with an optional touch-screen interface, SD memory card, Ethernet networking, a stepper motor driver, a real time clock and more. These add-on boards simply plug in and sample software is provided to interface with them.

Some of these add-on boards plug into the PORT headers which connect directly to eight of the micro's pins (and also have power supply connections) while others plug into one of the two "MikroBUS" headers which provide a standardised way to connect peripherals to a variety of micros. More on the ports later.

Mounting holes are provided at the corners so you can fit spacers or feet. As you can see from the photo, everything is clearly labelled on the white silk-screened overlay. The board is laid out neatly so you can find the header/button/LED you want without having to scan around and pretty much all the pin connections are configured using DIP switches or jumper shunts.

All in all, it's a well-thought-out piece of kit and considering what you get, the price is quite reasonable (more on that later).

Programming and debugging

Many other development environments provide you with only the C and assembly languages, which are great for advanced users but present a steep learning curve for beginners. BASIC is the easiest to learn but most limited while Pascal is closer to C in terms of capability but with an easier-to-learn syntax.

We suggest that anybody serious about embedded development should ultimately learn C (and perhaps assembly language too) but it's a lot easier to get your head around those languages if you have already absorbed programming concepts while using BASIC or Pascal.

Software

The CD which comes with the EasyPIC contains documentation and the software you need to use the on-board programmer module but it also has demo versions of all three compilers (or they can be downloaded from the MikroElektronika website). The demo versions allow you to write programs that use up to 2KB of flash. Beyond that, you need to purchase the full compiler software.

The included mikroProg programmer/debugger (which is permanently soldered to the EasyPIC PCB) can work in conjunction with the compiler IDE, to download new code whenever you finish compiling it. Alternatively, you can use the supplied stand-alone programming software to upload your HEX file (perhaps generated with a different compiler or development environment). But the debugging functions must be used in conjunction with the development environment.

So you can write or modify your software, send it to the PIC with a key press and if it doesn't work properly, immediately jump into debugging mode. This usually involves setting a "breakpoint" at a particular line of code and the micro will freeze before it processes that particular statement.

You can then examine the state of your variables and step through the program line-by-line, observing how variables and output pins change as you do (say, using the EasyPIC's on-board LEDs) until you figure out what's going wrong and fix it.

By the way, you can also buy a stand-alone mikroProg which is capable of programming and debugging any PIC, up to and including the PIC32 range, without needing to be re-flashed.

Features

The EasyPIC board can supply either 3.3V or 5V to the micro, set using jumpers. It can be powered from a variety of sources such as USB, a bench supply or an AC or DC plugpack. For programming and debugging, you simply connect the supplied USB cable to the board and your PC.

If you want to run the micro from a crystal rather than its internal oscillator, a socket is provided, along with a suitable crystal. There is also a socket

Cost & Availability

The EasyPIC v7 is available from Mostyn Enterprises, NSW, Australia. The price is $221.00, including GST & express post within Australia. Contact them on (02) 9834 1299 or visit **www.mostynent.com**

Mostyn can also supply some of the more popular accessory boards. These include:

Storage: Micro SD, MMC, Compact Flash, EEPROM

Communications: Serial Ethernet, Easy WiFi, WiFi Proto, Easy BlueTooth, CAN, RS485, MAX3232, USB UART/UART2, RFID Reader

Display: Graphics LCD, TFT LCD, Alphanumeric LCD 2 x 16, COG 2 x 16

Sensors: 3-Axis Accelerometer, Light-to-Frequency 1 & 2, Motion Sensor, SHT1X Temperature & Humidity

I/O: DAC, Easy DAC, ADC Proto, 4 x 4 Keypad, Relay 4, Port Expander, SmartMP3, Microphone Amplifier, Audio Amplifier

Miscellaneous: Bipolar Stepper Motor, Real Time Clock

Contact Mostyn for prices on the accesory boards.

for a second crystal for those micros with two oscillator circuits, eg, for use as a real-time clock.

To connect up the various micro pins to external circuitry, you use the pin headers on the righthand side of the PCB. These are grouped in sets of eight pins by port letter (PORTA, PORTB, etc) so you don't have to refer to the data sheet to figure out where to connect the rest of your circuit.

There are two headers for each port, wired in parallel. This can be useful if you plug in one of the add-on boards which doesn't use all the pins in the port; the other pins can then be accessed via the second header. They also provide solder pads for semi-permanent connections or to allow probing with a scope or multimeter.

Each port has eight pushbuttons, one for each pin; PORTE only has four since that's the most that any supported micro uses. The pushbuttons can be set to pull the corresponding pin either high or low; this is set for all pushbuttons at once with a single shorting block. There is also an 8-way, 3-state DIP switch for each port which allows you to enable a 4.7kΩ pull-up or pull-down resistor for each pin.

The pins of each port are also connected to a row of red LEDs (via series current-limiting resistor) and these can be used to view the state of each digital output. They are enabled on a port-by-port basis using DIP switches – ie, all eight for a given port are on or off. Glancing at the LEDs to see the pin states is a lot quicker than probing around with a multimeter!

Then there are a couple of small pots which can be used to drive the voltage level of one of several analog input pins on the micro. You use DIP switches to select which pins are connected to the pot wiper(s) and can then vary the voltage fed to the micro's internal analog-to-digital converter (ADC).

In addition to the type-B USB connectors for the in-circuit programmer/debugger and the USB UART (mentioned earlier), there is a third socket for those micros which have on-board USB controllers, so you can test and debug those functions too.

There are also sockets for connecting analog or digital temperature sensors.

Virtually all of the on-board peripherals can be connected or disconnected from the micro pins using banks of DIP switches. This way, you aren't tying up pins with peripherals you do not need for your application. In some cases, a peripheral can only connect to a certain set of micro pins while for others (eg, the UARTs), you have many options for which pins to connect them to.

Accessories

As mentioned earlier, a number of add-on boards are available. Some are designed to suit the EasyPIC v7 specifically while others are general purpose boards which can be plugged into the various pin headers. In fact, these accessories can be used with breadboards and custom PCBs too; all you need is a pin header with the appropriate connections to a PIC.

A list of accessories available from the Australian distributor (Mostyn Enterprises) is provided at the end of this article. MikroElektronika make over 100 different add-on boards, most of which are compatible with the EasyPIC v7.

We think the most useful and popular accessories will be the LCD modules, Ethernet interface, MMC/SD card board, accelerometer and the stepper motor driver.

Just how many accessory boards you can connect to the EasyPIC v7 will vary, depending on how many pins each of those accessories uses and which on-board peripherals you have enabled. You probably won't be able to plug in more than four, as these will then occupy most of the PORTA-PORTD pins. Some add-ons plug into the port pin headers while others connect to one of the two MikroBUS headers but either way, they occupy some of the limited number of microcontroller I/O pins.

Instruction manual

The instructions and software provided with the EasyPIC are top notch. The manual is large, full of great photos and clear diagrams. It explains all the features in detail, one at a time so that you can easily see how the various controls and connectors are wired up to the micro and power supply. In fact we would say that the instructions provided are among the best we have ever seen.

Conclusion

This is a good board for people who want to get into programming PICs or for those who develop a lot of different microcontroller-based designs and want to be able to engage in rapid prototyping. While you don't need an EasyPIC board or MikroICD to use the MikroElektronika compilers and development environment, they go together particularly well.

Most EasyPIC users will eventually design and build a custom board for their project. The software can be developed on the EasyPIC v7, where connections can easily be rerouted and probed (and you can even change PICs if you find the one you chose originally won't do the job).

Once the software and hardware is all working properly, the custom board can be designed and the software transferred across. SC

Jaycar Electronics

Better. More Technical

2012 CATALOGUE

APRIL EDITION

Price valid until 23/4/2012

LED Rotating Disco Light

A compact sound activated RGB LED party light that helps to create a fantastic atmosphere on any special event or occasions. It can be operated automatically to create very bright coloured patterns in red, green and blue with 61 LEDs. Very portable and durable.

- Mains powered
- Size: 200(L) x 108(W) x 160(H)mm

Due mid April

SL-3441

NEW $79.95

10MHz Velleman Rechargeable Handheld Pocket Scope

A complete portable oscilloscope with a tiny size. Aside from standard scope features, it has nifty tools for measurement of RMS speaker power, display hold function, and memory storage for 2 signals. Housed in a durable rubber surround with backlit LCD display and inbuilt Ni-MH battery. See our website or in-store for full specifications.

$249.00

- 10MHz
- Rechargeable
- CRO probe and USB charge cable supplied
- Size: 114(H) x 74(W) x 29(D)mm

QC-1914

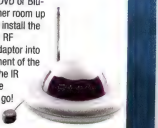
IR Remote Control Extender to suit PayTV

Control your Pay TV, DVD or Blu-ray player from another room up to 30m away. Simply install the rechargeable battery, RF transmitter and AA adaptor into the battery compartment of the remote control with the IR receiver in front of the device and away you go! Remote control not included.

- 3 selectable channels
- Mains adaptor included
- Size: 97(D) x 54(H)mm

AR-1821

NEW $59.95



Wireless Energy Monitor for Smart Meters

Monitor your household electricity consumption and costs in real time. Then use the historical records and bar chart analyse how much energy and money you can save. Easily program the meter with to estimate the usage cost per hour, day, month or any time period.

$119.00 NEW

Pack includes:

- Wireless Energy Monitor
- Power Transmitter
- Optical Sensor (500mm cable)
- Mounting hardware
- 4 x AA batteries

MS-6164

IP67 True RMS Autoranging Cat IV DMM

Features a large, easily read display and IP67 rating, making it waterproof.

- True RMS
- Cat IV, 600V, 4000 count
- Data hold & relative function
- Auto off & backlit display
- Diode test & audible continuity
- Autoranging
- 10A current range

QM-1549

NEW $79.95

Stereo 2.4GHz Digital Wireless Amplifier System

Send crystal clear audio from your Hi-Fi or portable music device to speakers up to 20m away without messy wiring. Connect your speakers to the spring terminals and power using the included power supplies or by batteries. Supplied with 2 x 150mm 3.5mm curly cables to connect your audio source.

$129.00 NEW

- Class T amplifier design
- Power output: 15WRMS x 2 (into 4 ohms)
- Transmitter and receiver requires 8 x AA batteries each
- Size (transmitter and receiver): 156(L) x 45(H) x 95(W)mm

AR-1895

Due mid April

Fast Battery Charger

Suitable for charging up to four AA or AAA Ni-H/Ni-Cd rechargeable batteries and has the ability to detect non-rechargeable, short-circuited or defective batteries.

- 4 LED indication
- Mains powered
- Size: 100(L) x 64(W) x 25(H)mm

MB-3564

NEW $14.95

Outdoor USB Solar Charger

The solar panel outputs 5 volts via a USB port. Using the included lead and adaptor set, you can charge portable devices such as media players and Smartphones.

- Output Voltage: 5VDC
- Peak Current: 500mA
- Size: 250(H) x 170(W) x 15(D)mm

MB-3593

NEW $44.95

NOTE: iPhone® not included

5W UHF Transceiver - 80 Channels

Amazing range and clarity suitable for long distance communication. Switch to power-saving 1W output for short distance communication. Includes Li-ion rechargeable battery pack, AC adaptor, charging cradle and belt clip.

- 80 channels with CTCSS
- Channel scan, dual watch, key lock, VOX, auto power save and repeater functions
- Antenna: 165mm long
- Size (without antenna): 130(L) x 60(W) x 35(D)mm

DC-1065

NEW $149.00

Ultra Slim LED/LCD TV Articulating Wall Mounts

Tilt, pan and swivel for maximum viewing flexibility - perfect for corner mounting flat screen TV. Allows 15° of tilt and 180° of swivel while mounting the TV only 32mm from the wall at minimum, and 642mm at full extension. Solid aluminium and steel construction. Mounting hardware and instructions included.

- Universal and VESA compliant
- Load capacity: up to 25kg
- Suitable for 32-55" flat screen TVs

CW-2852

NEW $119.00

To order call 1800 022 888

www.jaycar.com.au

GIFTS & GADGETS

Think ahead for Mother's Day!

Turntable with Speakers & Audio Output

Listen to vinyl collections directly from the unit and its built-in speakers. Features a 3.5mm headphone jack for personal listening with adjustable bass control. It has a line level output for connection to an external amplifier.

- 33/45/78 RPM
- Stereo amplifier
- Automatic stop
- Mains powered
- Size: 350(L) x 310(D) x 130(H)mm

GE-4136 ***Was $79.00***

$64.95
SAVE $14.05

Sabre SFX LED Sword

This sounds uncannily like the light sabre seen in the Star Wars® movies. It has a an eerie hum when held stationary and makes that famous swooshing noise when waved around. Changes colour & glows quite brightly.

$19.95

- Suitable for ages 8+
- Size: 710mm long

GT-3520

BUY 2 for $30 save $9.90

*Star Wars® is a registered trademark of LucasFilm Ltd.

Deluxe Automatic Soap Dispenser

Automatically dispenses a measured amount of liquid soap when you put your hands under it. No more touching soap bottles which reduces the risk of transferring germs.

- LCD with auto cleaning mode
- Requires 3 x AA batteries
- Size: 195(H) x 85(W) x 160(D)mm

GH-1188

$29.95

Water Misting Fan

Powerful enough to provide a significant breeze but safe enough for the kids to use with soft blades.

- Requires 2 x AA batteries

GH-1071

NEW
$8.95

6-in-1 Solar Educational Robot Kit

Introduce your kids to the world of solar power. This kit includes all the parts needed to construct up to six different projects of their choosing. Everything snaps together for easy assembly.

- Suitable for ages 10+
- Projects include: robot, helicopter, plane, windmill, airboat and three wheeler

KJ-8936

NEW
$19.95

Kids Earphones & Headphones

These specially designed earphones and headphones help prevent damage to hearing caused by listening to music at unsafe levels. Ideal for young children and teenagers.

- Built-in volume limiter
- Maximum output level: 85dB

Earphones AS-2084
Headphones AS-2086

$9.95
NEW

$14.95
NEW

1kg Digital Bench Scale

Precision 1kg electronic scale with resolution of 0.01g for when a high degree of accuracy is required. Weighs in grams, ounces, pounds, grains and troy ounces.

- Auto power-off after 60 seconds
- Automatic calibration
- Backlit LCD
- Tare and counting function
- Mains powered
- Size: 175(W) x 75(H) x 260(D)mm

QM-7264

$149.00
NEW

Rare Earth Fridge Magnets

Small in size but won't cover up your pictures, notes or shopping lists. These nifty fridge magnets are strong enough to hold up to 10 sheets of paper.

- Pack of 5
- Size: 20(H) x 11(Dia.)mm

LM-1629

NEW
$9.95

Bumper Bug Kit

Assemble this big green 6 legged bug and watch it alter its course when it bumps into a wall.

- Assembly time: 3 hours
- Suitable for ages 8+
- Requires 3 x AAA batteries
- Size: 203(W) x 70(L) x 151(H)mm

KJ-8956

NEW
$24.95

Electronic Bug Maze

An electronic bug habitat will keep kids entertained for hours. Comes complete with all the pieces required to build a beautiful home for the two electronic bugs supplied in the kit. Purchase additional kits and join them together to build bigger habitats for bugs to explore.

$29.95

- Suitable for ages 5+

YG-2893

Additional Electronic Bugs sold separately YG-2891 $4.95

Mini RC Helicopter with iPhone®/Smartphone Control

Control from your iPhone®/iTouch®/iPad® or Android™ Smartphone using free app available on iTunes®. A beautifully designed helicopter that is operated by connecting the infrared dongle to your device.

- 3 Channel
- Gyroscope for stable flight
- Includes rechargeable battery
- 30 min charge for 5 min flight time
- Infrared transmitter
- Robust alloy frame
- Includes USB charger
- Suitable for ages 14+
- Size: 135mm long

GT-3460 ***Was $79.95***

NOTE: iPhone® not included

$59.95
SAVE $20

Bubble Blower with LED Lights

Generates a fascinating display of bubbles that will have kids going wild. Simply insert the included 100ml bottle of liquid bubbles, click the trigger and watch it produce a consistent stream of bubbles.

$14.95

Buy 2 for $25 SAVE $4.90

- LED lights
- Requires 3 x AA batteries
- Suitable for ages 5+

AB-1230

Mini High Speed RC Stunt Car

Designed for thrills and spills with two protection rings that act as a roll cage. Supplied with a remote control and launch pad for stunt jumps. Recharge the car on the go with the battery powered charger pack.

- Requires 6 x AA batteries (remote & charger)
- 30 min charge for up to 9 mins play
- Suitable for ages 6+
- Size: 105mm long

GT-3293

$19.95

Two-Player RC Speed Bumpers

High speed bumper vehicles designed for thrilling head to head RC battles. Knock the opposing rider off its vehicle by making contact with one of the bumper tabs located on both sides.

$39.95

- Includes 2 x vehicles & 2 x wireless remote controls
- Requires 5 x AAA batteries each (vehicle & remote)
- Suitable for ages 10+
- Vehicles 125mm long

GT-3698

To order call 1800 022 888

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/04/2012.

ACCESSORIES TO SUIT APPLE® DEVICES

HDMI Cable & Converter for iPad®/iPhone®/iTouch®

HDMI AV Lead

The cable uses HDMI to stream audio and video to the big screen (TV, projector or even your home theatre audio setup). Supports movies and photo slideshows with video resolution up to 1080p.

- Compatible with iPad®1 & 2, iPhone®4/S, iTouch® 4th Gen
- Cable length: 1.8m

WC-7711

NOTE: iPhone® not included

NEW $69.95

HDMI Converter

Share and play your favourite songs, videos and photos on your TV or monitor from your Apple® device via HDMI plug. The USB port allows you to sync and charge the device for non-stop entertainment.

- Video resolution 720p
- Compatible with iPad® 1 & 2, iPhone® 4/S, iTouch® 4th Gen

WC-7713

NEW $64.95

Speaker with Aux-in for iPod® Shuffle

CRAZY PRICE

Specifically designed for the 2nd generation iPod® Shuffle. Its 1W+ 1W output power produces quality sound, and its protective cover makes it fantastic for use at the beach.

$5.95 SAVE $14

- Requires 4 x AAA batteries
- Size: 190(W) x 60(H) x 20(D)mm

XC-5189 **Was $19.95**

Headrest Mounting Bracket for iPad®

Keep the kids entertained on long journeys. Just mount the bracket to the metal bars on the car seat headrest and place the iPad® into the cradle. Couldn't be easier!

iPad® 1 bracket HS-9010
iPad® 2 bracket HS-9011

Note: iPad® not included

NEW $24.95

Docking Stations for iPhone®, iPod® &/or iPad®

AV Docking

Allows you to connect your audio and video devices with your iPod® or iPhone®. Features video output, audio jack and USB port designed to charge your device while connected. The dock comes with a full function IR remote control, AV & USB power cables.

NOTE: iPhone® not included

- Size: 88(W) x 74(L) x 19(H)mm

WC-7715

$49.95 NEW

HDMI Docking with Remote

Play slideshows or movies from your Apple® device on a big screen. Features HDMI video output, audio jack and USB port. The dock includes IR remote control, audio and USB cable and two silicone cases to protect your device.

- Supports up to 1080p video resolution
- Size: 72(W) x 68(L) x 28.5(H)mm

WC-7717

NOTE: iPhone® not included

$89.95 NEW

AV Cables for iPod®/iTouch®/ iPhone®/iPad®

AV Cable

Extend the multimedia capabilities of your Apple® device by connecting it up to a large screen TV, a projector, or even your home theatre audio setup. The cable uses RCA composite video to pipe video and audio to the big screen. See online for compatibility.

- Cable length: 1.5m

WC-7698

NEW $39.95

AV Component Lead

Connect an Apple® device to an HDTV, projector or the home theatre system via the Component RCA input. Features a USB connection to charge the Apple® device. See online for compatibility.

- Cable length: 1.5m

WC-7699

NEW $44.95

NOTE: iPhone® not included

Leads for iPad®/iPhone®/iPod®

USB Charge/Sync Lead

USB charge/sync lead suitable for Apple® iPhone®, iPod® and iPad®

- Length: 1m

WC-7693

NEW $7.95

Retractable Lead- to USB A Socket

Durable, retractable lead. Extend it to your desired length as required, retract it after you're done. Perfect for charging!

- White colour
- Length: 1m

WC-7730

$19.95

12VDC Charger Cradle for iPhone® 3/4

Holds and charges your iPhone® as you drive. Plugs directly into the car cigarette lighter and has charging cradles to suit both iPhone® 3rd and 4th generations.

- Power: 12VDC
- Includes a case/cradle for both iPhone® 3 and iPhone® 4

HS-9012

NOTE: iPhone® not included

$24.95 NEW

Bicycle Bracket Mount for iPhone® 3/4

Easily mount your iPhone® to the handlebars of your bicycle so you can take calls, navigate with your GPS app, listen to your favorite music, etc.

NOTE: iPhone® not included

- Size: 116(L) x 60(W) x 84(D)mm

HS-9016

$29.95 NEW

Universal Bracket for Mobiles & iPhone® 3/4

This handy bracket mounts an iPhone® or other mobile phone on the windscreen of the car where it's easily accessible.

HS-9014

Caution: The use of windscreen-mounted devices is illegal in some states, so check with your local traffic authority before using this device.

$29.95 NEW

NOTE: iPhone® not included

Horn Stand Amplifier for iPhone® 4

This moulded silicone horn holds your iPhone®4 and amplifies the sound up to 13dB. Fantastic!

BUY 2 FOR $15 SAVE $4.90

- Colours available in pink, white, green and blue

XC-5173

NOTE: iPhone not included

$9.95

EASTER CAMPING IDEAS

12VDC Switchmode Power Supply

A handy solution for powering 12V equipment such as car coolers and camping fridges from a mains AC power source. Supplied with a 1.5m output lead with cigarette socket output.

- 12VDC 12.5A
- input voltage: 240VAC
- Size: 200(L) x 100(W) x 65(H)mm

MP-3573

NEW $89.95

80 Channel UHF CB Twin Pack

Features a 3km range and an integrated LED torch. Perfect for camping, picnics in the bush, skiing and hiking trips. Supplied as a pair, in funky orange and green.

- 80 Channels
- Push to Talk (PTT) function
- Scan channel, call tone and monitor functions
- Requires 3 x AAA batteries per unit
- Size: 55(W) x 110(H) x 35(D)mm

DC-1003

NEW $49.95

Super Bright LED Torch with Magnetic Head and Telescopic Neck

A pen-sized torch with super bright LEDs and magnetic head for picking up objects. Extendable to 546mm and gooseneck at the end allows light to be shone around corners, into cracks and crevices.

- Size: 165mm long to 546mm extended
- Includes 4 x LR44 batteries

ST-3463

NEW $14.95

Fold Away UHF/VHF/Marine TV Antenna

Ideal for caravans and camping site this digitally ready outdoor antenna that works on all frequencies and includes a signal amplifier and a rotator motor built into the housing which is controlled by the included remote. Also includes 8m of TV lead with weatherproof plug.

- Remote requires 2 x AAA batteries
- Folds down for storage
- Antenna measures: 750(W) (deployed) x 30(L) x 100(D)mm

LT-3143

$59.95

80 Lumen LED Lantern

Weatherproof design and features 3 different light intensities & a flashing mode. Stands on flat surface or use the attached metal hook to hang the lantern anywhere.

- 6 x ultra bright white LEDs
- Requires 3 x AA batteries
- Size: 150(H) x 85(W)mm

ST-3123 ***Was $24.95***

$19.95 SAVE $5

Monocrystalline Solar Panels

A range of efficient solar panels with reliable performance and robust construction using tempered glass and aluminium frame. Size range from 5W to 175W. Fitted with junction box. See our website for more info.

NEW 90W Solar Panel (ZM-9086)

12V 5W	ZM-9091	$22.95
12V 10W	ZM-9093	$42.95
12V 20W	ZM-9094	$85.00
12V 40W	ZM-9095	$159.00
12V 65W	ZM-9096	$269.00
12V 80W	ZM-9097	$289.00
12V 90W	ZM-9086	$325.00
12V 120W	ZM-9098	$425.00
24V 175W	ZM-9099	$619.00

FROM $22.95

Solar Mobile Charger

Charge via direct sunlight or by connecting it to a power socket in your car or home. Recharge a range of different types of mobile phones, PDA's, MP3 players or digital cameras. Features two USB sockets and LED light function.

- Output power: 4.5-9W, 1A max
- Size: 125(L) x 24(H) x 24(W)mm

MB-3598

NEW $54.95

Brake Fluid Tester

Determines brake fluid quality by testing the percentage of water in the brake fluid which is indicated by five LEDs.

- Includes 1 x AAA battery
- Size: 150mm long

QP-2291

NEW $29.95

Pure Sine Wave Inverters

Provide bundles of power in mobile and permanent installations. They range in power from 180 to 2000 watts and have been selected and tested for their durability and design. In addition to the normal 240VAC outlet, all models have a USB port for powering all your gadgets.

WOW! NEW LOWER $33 PRICE

12V 180W MI-5160	$189.00
12V 380W MI-5162	$239.00
12V 600W MI-5164	$349.00
12V 1000W MI-5170	$599.00
12V 1500W MI-5172	$899.00
12V 2000W MI-5176	$1199.00
24V 2000W MI-5174	$1199.00

FROM $189.00

NEW 2000W/12VDC Inverter (MI-5176)

Stainless Steel Travel Mug with Built-in Heater

Has a built-in, thermostatically controlled heater and will maintain one of four selectable preset temperature settings ranging from room temp to very hot. Keeps your coffee, tea, or other beverages hot while driving.

- Stainless Steel construction
- Ergonomic handle

GH-1301

$29.95

260 Lumen Rechargeable CREE® LED Torch

Efficiency improvements in LED torches are allowing greater light power from small packages. This torch demonstrates that very well with the ability to output 260 lumens of white light from a battery that is slightly larger than a single AA. Great for every day around the house activities and more demanding uses such as hiking or caving adventures.

- Burn time: 5 hrs
- Size: 205(H) x 45(W)mm

ST-3453 ***Was $69.95***

$59.95 SAVE $10

12V Camping Shower

Plug into your car's cigarette lighter socket, add a bucket of warm soapy water and wash away. Ideal for camping. Plastic tubing, pump, showerhead, hanging hook and carry bag all included.

YS-2800 ***Was $24.95***

$19.95 SAVE $5

12V Portable Stove

Cooks, warms or reheats at up to 125°C. Deep lid design, with a case made from durable ABS plastic and carrying handles.

- Size: 265(L) x 180(W) x 155(H)mm

YS-2808 ***Was $49.95***

$39.95 SAVE $10

Emergency Caution Light

Compact and visible up to 800 metres away, this super strength plastic caution light contains a strong magnet for placement on vehicles in an emergency situation.

- Requires 2 x AAA batteries
- Size: 105(Dia.) x 35(H)mm

ST-3201

BUY 2 for $30.00 SAVE $9.90

$19.95

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/04/2012.

SECURE YOUR PROPERTY

Wireless IP Camera - 1.3MP

A great low cost, compact, remote security solution, enabling you to keep an eye on the safety of your pets, property, or loved ones. View live camera footage on your iPhone® or computer from anywhere there is internet access. Free management software for PC, iPhone® and Android™ phones.

- Motion detect record
- Resolution: SXVGA (1280 x 960) at 30fps
- Size: 78(H) x 68(W) x 27(D)mm

QC-3830

NEW $129.00

Due early April

Wireless Doorbell Alarm with Clock & Temperature

Suitable for the elderly or hearing impaired. A flashing blue light accompanied with 36 selectable doorbell melodies and a red flashing light with audible alarm are activated when the transmitter is used. The portable LCD chimer has a range of up to 80m line of sight. Time, date and indoor temperature are shown on the LCD.

- Doorbell transmitter: 45(W) x 16(H) x 90(D)mm
- Alarm Transmitter: 45(W) x 16(H) x 85(D)mm
- LCD Chimer: 115(W) x 25(H) x 175(D)mm

LA-5022

NEW $34.95

Wireless 7" Colour Video Doorphone with Recording Function

Monitor the front door of your home or office without the need to run wires. The weatherproof outdoor camera can be powered from the included power supply or from 6 x AA batteries (not included). The AV signal transmits wirelessly to the 7" colour monitor. It also records any visitors you had while you were out, saving the footage to an SD card (available separately).

- 2.4GHz for transmission up to 100m
- Weatherproof (IP55) camera with rain shield

QC-3621

NEW $349.00

Professional H.264 DVR with VGA & DVD Recorder

FROM $999.00 SAVE $500

Uses the Texas Instruments Davinci DSP and Techwell H.264 codecs, a real-time operating system and combines video and audio encoding/decoding, hard disk recording and multi-stream networking. These have the features of both DVR and digital video server capabilities, you can store or archive to DVD/CD, NFS/SAN or external USB mass storage device. Use either stand-alone or to build a powerful surveillance network.

BONUS SURVEILLANCE CAMERAS!! Camera* of your choice worth $200 for QV-3044 or $300 for QV-3045

8-Ch 500GB HDD QV-3044 Was $1499 Now $999 Save $500
16-Ch 1TB HDD QV-3045 Was $1999 Now $1299 Save $700

NOTE: For online orders, the camera value will be issued as refund/rebate at the time of order despatch. *List instore or on web.

Dummy Dome Camera Kit with Flashing Sign

A simple and effective visual deterrent that comes with a realistic-looking dummy dome camera and a flashing solar-powered 80 x 80mm LCD warning sign.

- Requires 3 x AA batteries
- Size: 120(Dia.) x 70(H)mm

LA-5324 *Was $24.95*

$19.95 SAVE $5

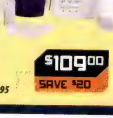
4 Zone Alarm System

The system utilises two-wire technology to ensure simple set-up for DIY enthusiasts. The unit has a built-in keypad with status LED and three modes of operation (Home, Out, Off). All sensors and sounders are line protected so any attempt to interfere will sound the alarm.

- Includes: control unit, 2 x PIRs, 4 x reed switches, external siren/strobe, cable, 240VAC Adaptor and mount hardware

LA-5475

Was $129.00



Accessories sold separately
2 Wire PIR LA-5476 $29.95
PIR Lens - Lens Curtain LA-5473 $6.95

$109.00 SAVE $20

IP68 3-Axis Cameras

High quality IP68 rated cameras with 3-axis movement through a wide range. Equipped with IR LEDs that works in darkness with a 20 metre range. Two models available:

Economical
380TVL
QC-8611
Was $129.00

FROM $109.00 SAVE $20

High Resolution 550TVL
QC-8612 Was $249.00 Now $229 Save $20

7" LCD Surveillance Monitor and 2 x CMOS Camera Kit

Powered from one plugpack, all power and video is run along a single integrated cable. The LCD monitor also has an audio input to add a microphone if required. See website for full contents.

- Camera resolution: 420TV Lines
- Monitor resolution: 480 x 234
- Camera size: 85(L) x 46(Dia.)mm
- Monitor size: 186(W) x 86(H) x 30(D)mm

QC-3640

Was $199.00

$149.00 SAVE $50

Steelmate Entry Level Car Alarm with Voice Function

An affordable car alarm that features voice feedback on alarm status and operational parameters such open doors etc.

- Includes electronic black box controller, shock sensor, ignition cutout relay, speaker siren, wiring looms, bonnet pin switch, car charger for the remote controls, extra circuits for fuel and ignition cutout, 2 x code hopping remote control units with a built in torch

LA-9003 *Was $99.00*

Also available:
Spare remote LA-9004 $37.95

$79.00 SAVE $20

18 LED Infrared Spotlight for Cameras

Use a surveillance camera in zero Lux conditions with the aid of this high-powered infrared spotlight. It has a waterproof metal case, and a built-in Light Dependant Resistor (LDR) to automatically switch on when the light level is below acceptable levels. Mounting hardware supplied.

- Size: 44.5(Dia.) x 27(D)mm

QC-3650 *Was $39*

$34.95 SAVE $4.05

19" LCD Security Monitor

Unlike most other LCD screens, this unit is fitted with a hardened front bezel capable of withstanding a massive impact. Features BNC/VGA/HDMI inputs allow for easy connection to your DVR or media player. This security monitor acts as an obvious visual deterrent, sits on a desk comfortably and can be mounted to a standard 100mm VESA bracket.

- Resolution: 1280 x 1024
- Size: 455(W) x 360(H) x 60(D)mm

QM-3576

$469.00

Note: Special order only. Call your nearest stores for details.

Flucard® PRO Wireless SD Card - 8GB

Gives a whole new dimension to capturing, storing and sharing of photos and videos wirelessly. Transfer and share precious moments from your digital camera to your PC, laptop, tablets or Smartphones without the need for cables. Great for travellers! See website for full features and specifications.

- 8GB storage for approx. 3000 photos (varies based on photo size)
- Plug & Play

XC-5620

NEW $99.00

Note: Accessories not included

3-Button Optical Mouse

A low profile, ergonomic 3-button optical mouse. Simple and easy to use.

- Resolution: 1000 DPI
- Zoom-in, zoom-out; page up, page down
- Plug and play
- Windows and MAC® compatible

XM-5243

NEW $9.95

Also available:
5-Button Wireless Optical Mouse XM-5248 $24.95

Android™ Smart TV Media Player

Powered by the Android™ operating system this smart TV media player will add a new dimension to your plasma or old CRT. You can access all your favourite internet sites, install and run Android™ apps, watch just about any movie from your media collection, play games, facebook, twitter, msn, youtube etc. Just plug in a USB hard drive loaded with movies or connect to a shared drive on your Windows/MAC®/Linux machine (via Ethernet or Wi-Fi) and start watching your favourite movies with ease. See website for more info.

- OS: Android™ 2.3
- Video output: HDMI/Composite video
- Size: 210(L) x 171(W) x 35(H)mm

XC-4208

$199.00

802.11n PCI-E Wireless Network Card

A simple upgrade for PC motherboards lacking Wi-Fi. Just slot it in a spare PCI-E port for 300Mbps wireless connectivity.

- Complies with wireless 802.11b/g/n standards
- Compatible with Windows and Linux

YN-8326

$34.95

2.4GHz Wireless Keyboard & Mouse

An all-in-one wireless keyboard and mouse solution perfectly suited to home or office PC applications. Features Qwerty keyboard and an ergonomically designed precision mouse with scroll wheel.

- Size: 435(L) x 125(W) x 18(H)mm

XC-5174

$24.95

USB 2.0 External 3.5" HDD Case

$34.95

Accommodates a 3.5" SATA drive up to 3TB in storage capacity. Lightweight aluminium case for increased portability.

- USB 2.0
- Size: 117(W) x 183(D) x 50(H)mm

XC-4669

Also available:
USB 3.0 SATA 3.5" HDD Enclosure XC-4667 $49.95

Mini DisplayPort® to VGA Converter - 1.8m

Connect modern computers with a Mini DisplayPort® to a conventional VGA display, such as CRT, LCD monitor or projector.

- Mini DisplayPort® 1.1a compliant
- Supports up to 1080p, 1920 x 1200 video resolution

WQ-7440

$29.95

Also available:
Mini DisplayPort® to HDMI Converter WQ-7442 $29.95
Mini DisplayPort® to Video Converter WQ-7444 $29.95

USB Business Card Scanner

Save your business card contacts directly to an Outlook/Outlook Express address book. Using optical character recognition extracts text from the business card and categorise it in to 13 different fields.

- Scans single or double sided business cards
- Supports multiple languages
- Size: 120(L) x 70(W) x 20(D)mm

XC-4908 ***Was $79.95***

$69.95 SAVE $10

Note: Laptop not included

600VA 375W Line Interactive UPS

Compact and completely self-contained, an ideal backup solution for your data or other important equipment. It has 3 surge-protected outlets as well as 3 outlets backed up by the UPS and RJ11 ports for protecting phone or fax lines.

- Output voltage 220VAC
- Backup time: 3 min at full load
- Cold start feature
- Software included
- Size: 268(L) x 180(W) x 80(H)mm

MP-5222 ***Was $109.00***

$89.00 SAVE $20

USB Portable Speaker

Connects to MP3 players, Smartphones, computers or any other audio source to play your favourite tunes with great sound quality.

- Rechargable
- Maximum power: 12W
- MAC® and PC compatible
- Size: 210(L) x 60(W) x 50(H)mm

XC-5197

NEW $29.95

Wi-Fi Remote Wireless IP Camera

The smallest IP camera we've ever seen! With its wireless network interface, the camera allows you to stream and record audio video images over your network or directly to your Smartphone (iPhones® or Android™ devices) and laptop on the go. Powered by a CR2 battery.

- 640 x 480 resolution
- Size: 30(Dia.)mm

QC-3368

$99.95 NEW

Cradle and adaptors available separately QC-3369 $29.95

FME to TS9 Adaptor

Suitable for USB modems and 3G capable mobile phones with a TS9 connector. It allows you to connect a range of antennas that use the most common FME connector.

AR-3317

NEW $16.95

USB Slide/Film Scanner

CRAZY PRICE

Easy DIY way of digitally archiving, sharing and saving cherished photos. Negative and slide holders included.

- Scan directly to your PC using the provided software
- 1,800dpi resolution
- Windows compatible
- Size: 85(W) x 165(H) x 90(D)mm

XC-4881 ***Was $74.00***

$45.00 SAVE $29

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/04/2012.

Pocket Sized Non-Contact Digital Thermometer

Featuring an easy to read LCD, this handy little unit can go with you anywhere. Handy for use in the kitchen or the food service industry to ensure proper cooking, grilling and storage temperatures.

- Pocket Sized with LCD
- Fast Response Time
- Temp Range: -35 ~ 230°C / -31 ~446F
- Battery Included
- Size: 74(L) x 40(W) x 20(D)mm

QM-7225 ***Was $34.95***

$29.95 SAVE $5

188pc Rotary Tool Accessories Pack

This kit will service every rotary tool bit you'll ever need. Includes sanding, grinding, cutting and polishing attachments and everything is housed in a case so you can see exactly where all the bits belong. See website for full list of contents.

- Case size: 210(W) x 320(H) x 52(D)mm

TD-2458 ***Was $19.95***

$14.95 SAVE $5

Precision Screwdriver Set

Set includes 3 Flathead and 3 Phillips screwdrivers. Ideal for working with computers, TVs. DVRs, radios etc. Supplied with a wall or stand bracket.

- Chrome vanadium steel

TD-2017 ***Was $13.95***

$9.95 SAVE $4

IP67 True RMS Autoranging CatIV DMM with Wireless USB

A quality true RMS multimeter with a wireless USB computer interface and includes logging software which allows computer based live data whilst keeping your computer completely isolated and protected. Double moulded housing and IP67 rated.

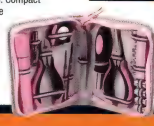
- Non-contact voltage indicator, data hold
- Backlit, auto off
- Diode test and audible continuity
- Cat IV, 600V, 4000 count
- 10A current range
- Size: 170(L) x 79(W) x 50(H)mm

QM-1571

$109.00 NEW

23 Piece Pink Mini Tool Kit

Good quality tools with rubberised grips. Compact and easy to store, comes in a carry case and perfect for doing repairs at home and office.



- 23 piece in total
- Size: 210(L) x 140(W) x 50(D)mm

TD-2067 ***Was $19.95***

$14.95 SAVE $5

Pro Gas Soldering Tool Kit

$69.95

A sturdy, portable, self-igniting butane powered gas soldering iron tool kit. Produces a 1300°C adjustable flame for low end brazing, tin/plastic melting, automotive repair work, welding and of course heat shrinking. Supplied with 3 interchangeable metal tips, plastic carry case, cleaning sponge and deflector.

- 80-100 min operating time
- Torch dimensions: 240(L) x 28(Dia)mm

TS-1113

Spare tips & butane gas available separately. See in-store or online for more details.

Bull Nose Pliers

Buy 2 for $10.00 SAVE $7.90

Made from hardened carbon steel with a micro-nickel finish. The handle has a matt red vinyl coating.

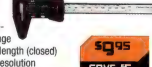
- TUV and GS approved
- 120mm / 4.5" long

TH-1889

$8.95

Budget 150mm Digital Vernier Calipers

The digital display is calibrated in imperial and metric units with a corresponding scale etched onto the caliper slide. Perfectly suited to the home handyperson.



- 150mm measurement range
- 245mm length (closed)
- 0.1mm resolution
- Includes 1 x SR44 battery

TD-2081 ***Was $14.95***

$9.95 SAVE $5

Retractable Alligator Test Lead Set

Set of 3 heavy duty red, black, and green leads on a retractable 3m reel, terminated with insulated alligator clips.

Reel Dimensions: 152(Dia) x 20(W)mm

WT-5334

$24.95

48W Temperature Controlled Soldering Station

Ideal station for the advanced hobby user. It features accurate analogue temperature adjustment, ceramic element and a lightweight pencil that will give you hours of fatigue-free soldering. The stand has spare tip storage and is very sturdy.

$79.00 SAVE $20

- Power: 48W
- Temperature range: 150 - 450°C
- Operating voltage: 24V
- Lead-free rated
- Size: 150(L) x 115(W) x 92(H)mm

TS-1564 ***Was $99.00***

Spare pencil & tips available separately

Non-Contact Voltage Tester/IR Thermometer

A precise non-contact AC voltage detector and IR thermometer in one. Provides easy and safe testing of mains voltages and heating systems in both Celsius or Fahrenheit.

- Detects AC voltage up to 1000V with LED indicator
- Size: 155(L) x 24(Dia.)mm

QP-2269 ***Was $59.95***

$39.95 SAVE $20

Also available:

Non-Contact AC Voltage Tester with Torch QP-2271 WAS $19.95 NOW $14.95 SAVE $5.00

Coax Cable Tester

Simplify your cable and connector testing with this handy tool. Connect it to the F-connector and it will give you an audible signal and a red/green go/no go signal to tell you if there's a short or an open in circuit on cable or connectors.

- Requires 1 x AAA battery
- 100mm long

QP-2289 ***Was $24.95***

$19.95 SAVE $5

Flameless Gas Hot Air Blower

A handy little unit for blowing hot air without the presence of a flame. Uses butane gas and has Piezo ignition. Great for general heating and drying.

- Refill with butane gas (**NA-1020** $5.95)
- Size: 148(L) x 35(W) x 23(D)mm

TH-1602 ***Was $29.95***

$19.95 SAVE $10

18 Piece Stainless Steel Mixed Bit Set

A collection of commonly used driver bits in a handy rubber edged case. All stainless steel. Driver not included.

- Contains: Torx: T10, T15, T20, T25, T30, T40
  Flat blade: 3.5, 5.5, 6.5
  Philips head: 1, 2, 2, 2, 3
  Hex: 4, 5, 6
- Case size: 115(L) x 50(W) x 31(D)mm

TD-2111 ***Was $29.95***

$19.95 SAVE $10

Also available:

21 Piece Stainless Steel Micro Bit Set with Driver TD-2110 Was $29.95 Now $19.95 Save $10

HOME THEATRE

Ultra Slim LED/LCD TV Tilting Wall Mounts

Ultra thin tilting wall brackets for LED/LCD TVs allow 15° of tilt and mount only 19mm from the wall. Heavy duty steel construction. Mounting hardware and instructions included.

- Load capacity up to 25kg
- VESA standard complaint

For 23" - 55" LCD/LED TV Sets
CW-2836 $39.95

For 40" - 65" LCD/LED TV Sets
CW-2838 $49.95

FROM $39.95 NEW

White Active Column Speaker

Boosts sound from your flat TV screen

Each speaker has three, 4" full range drivers that provide excellent sound reproduction. A built-in 20WRMS amplifier powers each speaker unit. RCA left and right inputs for external audio source connection. Mains IEC leads are also included.

- Voltage: 240VAC
- Size: 532(H) x 113(D) x 131(W)mm
CS-2439

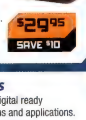
$299.00

Note: TV not included

Sold as a pair

Digital TV Signal Strength Meter

Take the stress out of installing your digital TV antenna. Connect the DVB-T meter then adjust the angle of your antenna until the LED indicator shows you've hit the right spot. Adapters included.



- Requires 1 x 9V battery
LT-3332 ***Was $39.95***

$29.95 SAVE $10

Digital Set-Top Boxes

Convert your old TV to digital so you can enjoy more channels (HD model), extra features and clearer reception. Mains powered.

Economy Standard Definition Set Top Box

- Composite video and audio left and right outputs
- Remote control included
- Size: 120(W) x 35(H) x 100(D)mm
XC-4914 ***Was $29.95***

$19.95 SAVE $10

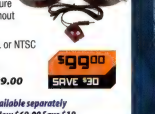
Standard Definition Set Top Box with Recording Output

- USB port for AV recording
- Composite AV and S-video plus digital audio and analogue left and right audio outputs.
- Remote control included
- Size: 189(W) x 40(H) x 117(D)mm
XC-4912 ***Was $39.95***

$24.95 SAVE $15

Watch Cable TV All Over The House

Easily share audio and video signals wirelessly from your cable TV or Blu-ray player. The powerful 5.8GHz transmitter and receiver provide excellent picture and audio quality without interruption.



Limited Stock

- Supports either PAL or NTSC
- Size: 105(W) x 150(D) x 38(H)mm
AR-1840 ***Was $129.00***

$99.00 SAVE $30

Additional receiver available separately
AR-1841 Was $79.00 Now $69.00 Save $10

UHF TV Antennas

Come in and see our range of digital ready antennas for all sorts of locations and applications. Here are just a couple of our top sellers:

43 Element UHF TV Antenna

Suitable for medium signal reception areas.

- Gain - 13dB
- Channels - 21 to 69
- Bands - 4 & 5
- Overall Length - 1234mm
LT-3181 ***Was $44.95***

$34.95 SAVE $10

91 Element UHF TV Antenna

Huge antenna suitable for deep fringe signal reception.

- Gain - 15 - 19dB
- Channels - 21 to 69
- Bands - 4 & 5
- Overall Length 2214mm
LT-3182 ***Was $89.95***

$74.95 SAVE $15

Class-T Digital Audio Amplifier Module

Ideal for any audio enthusiast that enjoys building and modifying speaker systems. The pre-assembled PCB is tiny which allows you to incorporate it into a wide variety of speaker systems.

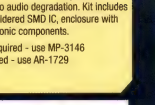
- Regulated 12VDC 2000mA required
- Size: 68(L) x 32(W)mm
AA-0228

NEW $29.95

Digital Audio Delay Kit

Refer: Silicon Chip Magazine December 2011

Corrects sound and picture synchronisation ("lip sync") between your modern TV and home theatre system. Features an adjustable delay from 20 to 1500ms in 10ms steps, and handles Dolby Digital AC3, DTS and linear PCM audio with sampling rate of up to 48kHz. Connections include digital S/PDIF and optical Toslink connections, and digital processing means there is no audio degradation. Kit includes PCB with overlay and pre-soldered SMD IC, enclosure with machined panels, and electronic components.



$99.95

- 9-12VDC power supply required - use MP-3146
- Universal IR remote required - use AR-1729
- PCB: 103 x 118mm
KC-5506

YOUR LOCAL JAYCAR STORE – Free Call Orders: 1800 022 888

• AUSTRALIAN CAPITAL TERRITORY

Belconnen Ph (02) 6253 5700
Fyshwick Ph (02) 6239 1801

• NEW SOUTH WALES

Albury Ph (02) 6021 6788
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Bankstown Ph (02) 9709 2822
Blacktown Ph (02) 9678 9669
Bondi Junction Ph (02) 9369 3899
Brookvale Ph (02) 9905 4130
Campbelltown Ph (02) 4620 7155
Castle Hill Ph (02) 9634 4470
Coffs Harbour Ph (02) 6651 5238
Croydon Ph (02) 9799 0402
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Midland Ph (08) 9250 8200
Northbridge Ph (08) 9328 9252
Rockingham Ph (08) 9592 8000

Arrival dates of new products in this flyer were confirmed at the time of print. Occasionally these dates change unexpectedly. Please ring your local store to check stock details. **Prices valid from 24th March to 23rd April 2012.**

HEAD OFFICE
320 Victoria Road, Rydalmere NSW 2116
Ph: (02) 8832 3100 Fax: (02) 8832 3169

ONLINE ORDERS
Website: www.jaycar.com.au
Email: techstore@jaycar.com.au

Jaycar electronics
Better. More Technical!

PRODUCT SHOWCASE

The Ultimate Home Entertainment Experience

With warm autumn weather still around and less rain than we had during summer(!), there is no better time to embrace the alfresco lifestyle and revamp your outdoor entertaining space. Why not be the envy of all your friends and invest in an open-air cinema for the home by Smart Digital?

HandiTheatre is the only self-contained inflatable movie screen in Australia that allows you to enjoy the full cinematic, gaming and Blu-ray experience in your own backyard. It is the perfect excuse to pull out the beanbags and plan a girls' night in with the latest romantic comedy and a few buckets of popcorn – or a lads-only sports session.

With the sound and image quality of the high definition HandiTheatre being second-to-none, Blu-ray DVD's and games look incredible on screen and being completely portable you can take it anywhere – whether it be on holiday or just around to a friend's place – and what's more, the screen doesn't require constant inflation so once set up you can sit back, relax and enjoy your movie night under the stars.

The HandiTheatre screen is available is two sizes (measured diagonally) – 3 metres for $3,998 and 2.5 metres for $3,498 and offers Blu-ray player, plug-in for games consoles (Playstation and Xbox), live TV function, screen, blower, speakers and capabilities for accessories such as video

cameras and PC.

HandiTheatre will revolutionise your entertaining, so make the most of the beautiful weather and create an outdoor experience your guests will never forget!

HandiTheatre can be purchased online at www.smartdigital.com.au

Contact:
Smart Digital Australia Pty Ltd
Unit 8, 52 Corporate Blvd Bayswater Vic 3153
Tel: (03) 9729 6300 Fax: (03) 9729 6622
Website: **www.smartdigital.com.au**

Hey, Charger!

If you're away from a power source with an iPad, iPhone or iPod (or most other phones) you'll know how frustrating it is when you run out of battery

Avcomm have come up with this nifty solar charger pack which can keep your phone (or other battery device) topped up simply by aiming it at the Sun.

The 250 x 150mm "Solar Collector" features a 2W solar panel which gives a stable 5V, 500mA output – so anything which normally charges (or can charge) from a USB port can be charged from this. They claim a one hour Sun charge will give you 1-2 hours "talk time" on your mobile.

A four-LED display tells you how the charging is going.

It comes with a variety of plugs to suit a variety of phones and has a back bag which can also hold your phone, iPad, etc.

It retails for $32.95 (Cat no. Q3060).

Contact:
Av-Comm Pty Ltd
24/9 Powells Road, Brookvale NSW 2100
Tel: (02) 9939 4377 **Fax**: (02) 9939 4376
Website: **www.avcomm.com.au**

"Stunning" Turntable

The new Rega RP6 Turntable has arrived with sound, engineering and finish which can only be described as stunning.

Available in eight high gloss finishes, the RP6 comes with the latest RB303 tonearm, dedicated outboard power supply with electronic speed change, double brace plinth technology for extra rigidity and a 16mm glass mass-loaded flywheel platter, all for just $1,799 RRP.

Contact:
Synergy Audio Visual
107 Northern Rd, Heidelberg Heights, Vic 3081
Tel: (03) 9459 7474 Fax: (03) 9459 4343
Website: **www.synergyaudio.com**

WiFi SD Card – without the o'seas hassle!

Regular readers may recall the difficulties we had in obtaining a WiFi SD card from overseas a couple of years back. Now Jaycar Electronics have introduced a similar card without the hassles – you can get it at any Jaycar store or reseller.

The 8GB Flu Card Pro card is compatible with any device with an SD host slot. Just plug it in and its built-in software will instantly transform your Digital Camera into a Wi-Fi device (802.11 b,g or n), ready to transfer pics, share them with friends, etc over WiFi. It's a great idea!

It sells for $99 inc GST (Cat no XC-5620).

Contact:
Jaycar Electronics (all stores)
PO Box 107, Rydalmere NSW 2116
Order Tel: 1800 022 888 Fax: (02) 8832 3188
Website: **www.jaycar.com.au**

SERVICEMAN'S LOG

The earthquakes finally killed my TV

Dave Thompson*

The Christchurch earthquakes damaged a lot of electronic equipment, including large-screen TVs. Mine was knocked flying off its stand on several occasions but it kept working until finally there was one quake too many.

Items Covered This Month

- The earthquakes finally killed my TV
- Traffic direction system for a ferry boat
- Shipyard plasma cutter
- Oyster-sorting machine
- Hydroponics control system
- Intermittent Commodore engine
- Mobility scooter intermittent

**Dave Thompson, runs PC Anytime in Christchurch, NZ.*

I don't want to sound like a broken record but this story involves earthquakes. To be fair, we have had about 10,000 of the blighters and while most countries get one good one and a few decent aftershocks from a single fault line, we've had a dozen really scary shocks plus the aforementioned 10,000-odd aftershocks – and these are coming from three completely different fault lines!

One wonders what we must have done to offend the Gods so deeply. Whatever it was, we must have had great fun doing it!

When the first earthquake "swarm" hit, our TV set wasn't that old. I had ditched our old clunker about three years previously and while its 20-inch CRT screen had been considered a middle-sized set when new, it had since become a "tiddler" in the scheme of such things. It was a reliable, well-known brand and the tube was still bright and sharp, even after 12 years of daily use. It's currently sitting under the bench in my workshop in perfect working order but the same can't be said of its successor.

The flat-screen LCD TV that took the CRT set's place was an 81cm model. It was made by a well-known computer monitor manufacturer so it's not the first name you'd think of when buying a TV. Nonetheless, it was an excellent unit with a picture that was superior in many respects to many better-known models but for about two-thirds their cost.

Our TV sits on the top of a solid-timber cabinet with the usual drawers and cupboards underneath for old remotes, playing cards and spaces for other home-entertainment hardware. Despite this, during the first big quake, it ended up face down on our lounge-room floor, surrounded by CDs and DVDs (many of which had mysteriously come out of their cases) and the usual quake detritus of broken this and smashed-up that.

As if the TV launching into space wasn't bad enough, the rest of our gear suffered as well because all the cables, which are about a metre long with the usual mix of RCA and TV-type plugs, remained steadfastly connected to the VCR, DVD player, antenna wall socket and the home-theatre system. These cables usually run from the back of the TV and connect to the various other devices after threading through a nicely-drilled 100mm hole in the back of the cabinet.

Unfortunately, as the TV flew into the room and the cable slack played out, the VCR and DVD player were hauled backwards and tried to escape through that 100mm hole. As soon as they hit the back of the cabinet, the cables stretched and either snapped or sheared off at the sockets, allowing the now-untethered TV to continue its trajectory into the centre of the lounge room.

After getting over the initial shock of a big quake, we took stock of the damage. The lounge room was a war zone and since we had no power for the rest of that day and there were dozens of equally scary aftershocks, we thought it best to leave everything where it lay – the theory being that our stuff couldn't fall any further or break any more than it had already.

When things had settled down and we had power back on, I put the TV back in its usual spot, dug out some replacement cables and rewired the whole thing back together. I left the VCR out since some of the sockets had been damaged and we hadn't used it for ages anyway. Amazingly, everything else worked and aside from some nasty scratching on the top and front of the TV cabinet, we were back in business.

Bigger brackets

I spent a lot of time following that quake making brackets and anchoring all our bookshelves and other stuff to the walls. However, subsequent quakes simply ripped these brackets out, damaging the walls and bookcases as well. Now we have really big brackets in place and if they fail, we'll have bigger problems to worry about than damaged equipment.

Unfortunately, there was no satisfactory means of anchoring the TV and since the worst of the aftershocks seemed to be over, I didn't worry about it. Then came the Boxing Day quakes and down it came again. There were more scratches and more sheared cables but everything still worked and so once again I didn't worry about securing it – after all, how unlucky could we be?

My optimism was sorely misplaced. Along came the February 22nd quake

and it proved to be the most damaging of all the quakes, even if the figures didn't confirm it. It really made a mess but even though the TV did its usual flight across the room, it still worked when I plugged it all back in.

The aftershocks then came thick and fast so we left the TV on the floor and watched it like that for a while. Its cabinet was by now well and truly ruined with deep scratches and I was getting sick and tired of buying new cables! But we were very lucky – most people we knew lost a lot more than their TV!

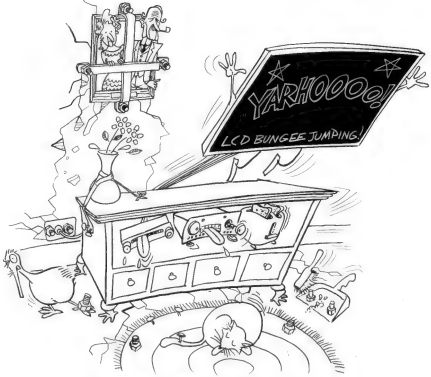
And then came the December 23rd quake. We'd not had a significant quake for months (the TV had survived the previous June quakes) and people were breathing sighs of relief and had begun putting the good china back on the shelves. As before, we were out when the quake hit and we arrived home to the usual "TV in the middle of the floor" scenario. However, this time I wasn't so lucky because when I put it all back up and plugged it in, it was dead. There was nothing at all; no lights, no picture, no sound – nothing! And just as all the stores and suppliers were closing for Christmas!

That was it then; there was nothing for it but to pull it to bits and try fixing it myself.

Now I don't do a lot of TV repairs but I've certainly repaired plenty of monitors and I've even been shocked by one, so that qualified me to have a look at least. I began by removing the case screws, a dozen heavy "PK"-style jobs, that hold the back on. However, to get the back off, I also had to remove the solid metal base and the mounting plates. These are held on with eight decent-sized machine screws.

Having done this, I found that the front and back were clipped together but not so tightly that I had to damage anything to get them apart. I used a plastic case-prying tool to work my way along the edge and "crack" the case as I went. When the last clip let go, the back easily came free, revealing the tuner, power supply and backlighting modules. The inside was beautifully laid out, the cables clipped in looms and everything well-shielded by a thin aluminium sheet which covered almost the entire back of the screen.

I spotted the tell-tale signs of trouble almost immediately. There were several blackened areas on the power supply board and I could also smell the burnt electrical components. The burnt areas looked nasty and I immediately knew that this was probably not going to repairable, at least not before Christmas.



~THESE CABLES CONNECT THE OTHER DEVICES THROUGH THE BACK OF THE CABINET

The only thing I could do at that stage was remove the power supply board and try to determine what had happened. Despite the evidence, I was still hoping that the fault might be something simple which I could fix, although I now knew full well that this was unlikely.

The power supply PCB was easily removed by undoing four small machine screws. And when I lifted it clear, I could see that two solder joints had somehow touched the grounded aluminium shielding underneath, the corresponding black electrical "splats" clearly indicating exactly where it happened. The component leads at these points projected less than 2mm below the board, which means that the board must have flexed about 8mm to be able to touch the aluminium (it sits on 10mm spacers).

To test this theory, I sat the 2mm-thick PCB back on its spacers and pushed as hard as I could in the middle of it. I could barely flex it!

Considering the two burned points were only about 30mm from one end of the board, I found it hard to imagine how the board could possibly have flexed that much or how the aluminium sheet could have moved so much. I also wondered what was so different about the TV hitting the floor this time around to have caused this fault. After all, it had survived half a dozen other trips to the floor.

Blown to smithereens

Closer inspection of the dead board showed two sections where surface mounted components had probably been present. It was hard to tell, because anything that had been present had been blown to smithereens and the tracks under the board burned away. Google revealed nothing as far as images or circuits for this board, so basically I was up the creek.

There was simply no way to fudge my way through fixing this board.

And that's the way it stayed. I reassembled the set and four days later purchased another, bigger and more up-to-date "smart" TV, which is screwed solidly to the top of the TV cabinet. I put in an earthquake claim for the old one and it is still sitting there in the workshop, dead and unlikely to ever go again.

However, I live in hope that one day someone may bring one in or I'll hear of one with a cracked screen and a good power supply board. Until then, we'll make do with the new one and

the old one can continue to gather dust; I can't bear to throw it out.

Technologically challenged

There's a trend for engineers and technicians from all walks of life to have a laugh at the expense of those we consider less technically capable than ourselves. After all, we've all sniggered after reading about the woman who used her CD-ROM drawer as a coffee-cup holder. And we could barely contain our disbelief when we heard about the guy who held a piece of paper up to his monitor, thinking that's how a computer fax worked.

But don't think that this is necessarily a modern phenomenon; 30 years ago, we were laughing at the lady who used the manual choke knob on her car to hang her handbag on and we chuckled at the guy who mounted an extra spark plug behind the grille of his car in order to defeat early traffic radar.

Whether these stories are urban legend or not, the fact is that people have always had a varied experience with the technology of the day. It's now even more common for people to get confused with the electronic gizmos that are available today and which have reached new levels of sophistication and complexity.

Even those of us with skills in multiple technical disciplines sometimes have trouble finding our way around some modern technology. Certainly, it's becoming increasingly difficult to stay up with every facet of every field.

It's always been true that what is intuitive and simple to one person can be completely befuddling to another and technical types often make fun of those who struggle with technology. Perhaps I'm being a little harsh on technical people here but to be honest, I don't see dentists running on-line forums specifically to make fun of people who don't know their alveolus from their fraenum. Nor do I see mortgage brokers pointing and laughing at those of us who can't get their heads around revolving credit or table loans!

So why then do some of us get such a kick out of watching people trip over technology? Personally, I have always found running down the technologically-challenged to be a bit cheap and tawdry. Part of my own repair company ethos is to never patronise clients or put them in a position where they feel silly.

Of course, this is actually tougher than it sounds, which is why a good proportion of our staff training focuses on just that. That doesn't mean we can't have a laugh (or groan) at the folly of grown adults. After all, you only have to peruse sites like YouTube or the Darwin Awards to know there are more genuinely stupid people out there than there should be.

Unfortunately, such people and servicemen regularly cross paths.

Basically, I'm talking about the things some people do because they simply don't know any better. While I'm not sure about the stereotypical Australian male, Kiwi blokes will generally have a go at repairing anything from their dishwasher to their kid's braces (often to the point of destruction) before conceding they might actually need to get a professional in to do the job.

To be fair, "having a go" is a global characteristic, even if typically found among the male of the species. While some of this behaviour could be put down to financial necessity, a large amount boils down to testosterone-fuelled, bloody-minded stubbornness and the refusal to accept defeat – something that can happen all too often with technology and engineering.

The fact is, service people from all walks of life see far too many instances of products and hardware in far worse shape than they should be, all because somebody thought they'd save time and money by doing the repair themselves (or getting their brother-in-law to do it).

I don't know if this happens in other trades but I have had far too many people call my workshop and ask me to walk them through certain aspects of computer repair. It's happened so often that I eventually created a specific phone script to deal with the situation.

Many computer repair technicians I've spoken to report similar scenarios. You really do have to wonder how anyone could be so cheeky. After all, just imagine calling your local mechanic and asking him to walk you through replacing the brakes on your car. What would any normal person expect them to say and do?

For us, it's always a bit of a tightrope walk between telling the caller to go away and wanting to help them out. In the vast majority of cases, we are able to turn things around and snare the job, along with a customer who is happy to pay for the work.

Unfortunately though, about 10% of callers can be quite rude about the fact we that won't help them out over the phone for free and give us all kinds of grief. As I've said before, service work is tough going sometimes.

A mixed bag

Now for a mixed bag of servicing stories from G. S. of Montrose, Tasmania. He runs a small business that designs and constructs electrical and electronic control systems for machinery, marine and agriculture applications. Here how he tells it . . .

My service jobs are mostly limited to my own products. In theory, this means that such jobs should be pretty easy since I have such a good insight into the equipment.

Oh yeah . . . I wish!

The first incident I'm about to relate concerns a traffic direction system fitted to a large ferry boat. Each traffic lane was fitted with a large LED panel which is controlled by a local microprocessor. This allowed the panel to display a moving arrow indicating go left, go right, turn left and turn right in response to a signal sent from a central control unit.

It was a very simple system in that the crew simply pressed a button on the control and an associated number

(1-9) was sent via a RS485 link running at a sedate 300 baud. The panels all over the ship would then display the appropriate direction arrow to allow cars to be loaded and unloaded; all very simple.

However, it was reported that one panel would not display properly. When trying to show an arrow running left to right it would start out OK but then decay into random flashes from the LEDs about half-way across. Conversely, when running from right to left, it would start in mess and finish as a clean arrow.

Each display consists of an 8 x 16 (H x W) LED matrix driven by Micrel serial in 8-bit parallel out latched drivers, so each row of LEDs had two drivers in series. These Micrel drivers are addressed by a Motorola 68HC705C8 processor. The output enable pins for all the driver chips are connected, to allow updates only after data shifts, and the LEDs are fully on when selected rather than scanned.

Sliding the panel out of its housing revealed nothing obvious. The enclosure was well-sealed, with no sign of dampness which is the usual culprit in marine situations. I got the panel running on the bench and it still showed the same problem which was a plus. I then removed the processor and plugged in the emulator and adjusted the program so that the arrow shape crawled across the panel.

Sure enough as the second shift register group became involved, bits of the arrow started to disappear and the LEDs would light randomly. A couple of runs showed it happened at the same spot in the scan, ie, when it moved from one shift register to the next.

It was time to look at the register chips. All the soldering looked good but a closer view with a strong light and a magnifier revealed a tiny strand between the clock and serial data pins on one of the chips. A quick flick with a knife cured the problem.

My next story concerns a fault in the main plasma cutter at a shipyard. It was an early, massive, flatbed machine with a basic control system that enabled it to cut plate in accordance with co-ordinates that are manually entered. The settings are shown on a large 7-segment LED display and the complaint was that the display would not show anything that made sense. In fact, as I quickly discovered, the display was flashing randomly.

The control unit simply slides out of its compartment. Unfortunately, it's fully enclosed and there's no way to keep the power on with it withdrawn. Clearly, there was little point in removing the cover at the machine so I took it back to the workshop and dismantled it there.

It came apart quite readily and this revealed a large array of 4000 series CMOS chips on a large PCB. The power supply was still in the machine but I was able to solder a couple of wires to the PCB and get it powered up. The 7-segment displays were driven by a group of 4511 decoder drivers and when powered up I expected to either see nothing or zeros.

Instead, what I got was random flashing zeros, similar to what was happening when it was installed in the machine. At that point, I suspected a dry joint on the IC that controlled the latch inputs to some of the display ICs. A measurement on one of the update lines revealed that the voltage was floating all over the place, so it was randomly causing data for other parts of the display to be mixed in.

Working my way across the board I arrived at a 4011

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quad 2-input NAND IC. There was no sign of a bad joint but the output from this chip to the display ICs was floating, despite the input being solid. A quick trip to the local Jaycar store for a replacement and all was well.

Moving on, an oyster-sorting machine that was on field test was returned with the complaint that it would not recognise oysters over 99 grams.

This machine has two separate channels. Oysters enter at one end, having been cleaned and separated by preceding equipment. They are then scanned by a photocell arrangement which measures shell length and are then passed to a load cell which measures their weight. After some on-the-fly maths, a decision is made on the "grade" of oyster, based on the two figures obtained, and the animal is discharged out an appropriate chute.

The load cell on the offending channel was clean and moved freely but static tests revealed that it would not give proper readings above 99 grams. And as it was only happening on one channel, comparison tests were easy.

The load circuit consisted of the cell itself and this fed an off-the-shelf amplifier, followed by an A/D converter with a multiplexed BCD output.

This in turn is controlled by a 68HC05 microprocessor that does all the housekeeping and the calculations. I swapped the converter boards between channels and found that the problem moved with the board.

The faulty board was a bit dirty due to the client's habit of leaving the enclosure door open. A close look with a magnifier revealed what looked like metal flakes on some of the digit address pins. A decent wash cured the problem and I cleaned the other boards while I was at it. My conclusion is that one of the address lines was shorted by a speck of rubbish on the PCB.

My next story involves a hydroponics control system which I had built and installed. The set-up consisted of several stacked trays interleaved with artificial light and was used for growing spinach and other leaf crops. A large tank held water and nutrients and was pumped in a loop for circulation, with the conductivity and pH measured by probes in the circulation line.

The whole arrangement was mounted in a shipping container which was powered via a 20-metre cable plugged into a service pole. This all worked nicely for several months until recently when the client complained that the pH reading kept running to extreme alkaline when the circulation pump was run. The tank pH measured 6.4 but the circulated water was going over 8 when being pumped.

A couple of enquiries on the net revealed that such problems can be caused by a potential difference between mains Neutral and Earth. The probe supplier agreed with the diagnosis so I had a local electrician take some measurements and he discovered a potential difference of almost 1V between these two lines.

So, where did this suddenly come from? The electrician confirmed that the MEN (Multiple Earth Neutral) was intact and the supply phases were reasonably balanced, so this pointed to the pump. The client then stated that he had changed the pump during an upgrade and it was a magnetically-coupled sealed-case type, as was the previous unit.

It then occurred to us that during the upgrade, the mains lighting had also been replaced by low-voltage DC lighting powered from three rather healthy 3kW 48V DC supplies. These contained suppression components between Active, Neutral and Earth, so perhaps their combined natural leakage current was causing the problem?

I rounded up a Burr-Brown(TI) ISO124 isolation amplifier and a 24V to isolated ±12V DC converter and built it up on a piece of stripboard. Once on site, I removed the pH amplifier board and cut the power, ground and output tracks to the input amplifier from the probe. Next, using short wires, I soldered connections from these tracks to the stripboard-mounted power supply and amplifier, thus inserting the isolation amplifier into the pH amplifier circuit and breaking the ground loop that was probably causing the problems.

And that solved the problem. However, it was a bit rough and ready so I subsequently modified the pH amplifier PCB to include the isolation amplifier and replaced it in due course.

~AN OYSTER-SORTING MACHINE WOULDN'T RECOGNISE OYSTERS OVER 99 GRAMS

Intermittent Commodore

Intermittent faults in cars can be both frustrating and difficult to track down as G. C. of Toormina discovered recently . . .

My daughter and son-in-law have a 1995 VS Commodore Acclaim which has been a very reliable vehicle. However, a few months ago, the engine began cutting out, usually at the most inconvenient times such as in peak-hour traffic.

At the first opportunity, my son-in-law and I decided to see if we could track the problem down. We replaced the fuel filter, checked all the hoses and wiring for loose connections, and checked the spark plugs and their leads. We also checked for steady power at the fuel injectors.

Despite going over it carefully, nothing could be found and the car was

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in SILICON CHIP? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

Intermittent mobility scooter

J. B. of Cookernup, WA recently encountered some frustrating intermittent faults in a mobility scooter. Here's how they were solved but first he describes a hair-raising experience . . .

One of my scarier repair successes was with a hairdryer. This one was a simple affair that hung off the shoulder with a hood to cover the hair and with just heat-setting, fan-speed and on/off controls. Such a simple arrangement should be trouble-free you would think but its owner complained that, on any setting, it either ran at full heat or blew cold air.

When I opened the handset control and traced the wiring, it became obvious that it must have been assembled on a Monday, as the Active and Neutral wires were transposed and, what's more, the bi-metallic switch had been bypassed. Just re-wiring it solved the problem but I hate to think what could have happened.

My most recent success was with a mobility scooter that we acquired some years ago to allow my wife to get around the shops independently.

Not long after purchase, it developed the curious habit of suddenly stopping for no apparent reason. Then, after switching it off and on again, it would behave as normal. Even when tested under warranty and fully serviced this fault did not disappear, so we put up with it for several years.

Then, at a local expo I happened to get into a discussion about the fault with the owner of a disability shop who explained that the little lever that you use for forward/reverse control was the culprit. And so, the next time I was in town, I had a talk with our local agent and he concurred with the diagnosis. As luck would have it, he had just replaced one of these control levers and he gave me the old one.

The item in question is simply a 5kΩ potentiometer with a spring-loaded lever (instead of a knob), the whole lot mounted on a metal plate. The spring, which attaches to the plate, holds the lever (and thus the pot) in centre position. It's manufactured in Mexico and the assembly retails for over $100.

The solder terminals on the unit were perfect (according to my multimeter), so I next took a close look at the connector plug. The wiring to this connector was very fine and it used crimped connectors inside the housing, so I decided to solder these to eliminate any contact problems. This instantly reduced the frequency of the problem but it still reappeared at unusual intervals, so I cut out the connector and directly linked the wires.

Doing this almost eliminated the fault but after a few more hiccups, I lifted the main body plate/footrest from the frame and found another connector where it connected to the main control unit. I bypassed that as well and placed the wiring properly in the channel, as at least one lead was being pinched which could account for the fact that sometimes wriggling the machine would bring it back to life. However, the main fault seems to have been in the crimped connectors.

Further checks revealed yet another connector near the motor itself. The wiring from this ran to an electromagnet mounted at the back of the motor and which is part of the braking system. The brake itself consists of an electromagnet and a spring that pushes a steel plate onto a fibre plate that is keyed onto the motor shaft. When the electromagnet is energised, the motor can run as the spring-loaded plate is pulled back.

I bypassed this connector as well. The scootor is now trouble-free – provided we remember to charge the battery on a regular basis.

behaving itself. And that meant we could only hope that the work we had done had somehow fixed the problem.

Unfortunately, Murphy was quickly up his tricks because as soon as I was out of town, the car cut out again and left my daughter stranded by the side of the road. She called the NRMA and they couldn't get it started, so they towed it to a repairer.

Because it was late afternoon, the car had to be left there overnight. The next afternoon, the mechanic called and said that the car was ready to be picked up. The diagnosis was a faulty crank-angle sensor. "It's fairly common on this model mate", was the comment as the mechanic extracted his tidy some of money.

Well, all was good for about three weeks and then the car suddenly stopped again. As before, the NRMA turned up and couldn't get it started, so it went back the mechanic for another overnight stay.

This time, the diagnosis was a faulty DFI module and I wondered if this might have been the real problem the first time. Anyway, we parted with another tidy sum of cash only to have the car die again just two days later.

And so back it went to the mechanic who again diagnosed a faulty crank-angle sensor, despite the fact that it had only been replaced a month earlier. It was replaced free of charge but of course, it wasn't the problem and the car died again a few days later.

As luck would have it, I now had a few days off work and so I decided to have another go at it. I have a manual for the vehicle, so I checked the wiring diagrams and decided to solder a LED and a series 560Ω resistor between the +12V terminal of the DFI unit and ground. I also connected a LED to monitor the +12V line to the fuel injectors.

I then told my daughter and son-in-law to check whether these LEDs were on when the car refused start. If they were off, then at least we would know where to start looking.

As luck would have it, I was in the car when it died again a few days later. I couldn't wait to pop the bonnet to check the LEDs but they were both lit, indicating that the supply rails to the fuel injectors and DFI module were both OK. And that eliminated the associated relays, fuses and wiring associated with those systems.

I then asked my son-in-law to try to start the car and this time it started but was running a bit rough. The LEDs remained steadily lit so I tried wriggling various connections. And when I wriggled the plug that attaches to the DFI module, the motor cut out. We then tried starting the motor again while wriggling this connection. The motor could be made to stop and start at will. Gotcha!

Having located the fault, the cure was relatively simple. We went to the wreckers and cut the DFI plug and about 300mm of the wiring loom from another VS Commodore. We then cut the old DFI plug off our Commodore, stagger-cut the wires on the new and old looms and soldered the wires together, heatshrinking each one as we progressed

Finally, I wrapped all the heat-shrinked joins in black insulation tape.

And that was it – the car is now completely reliable again. **SC**

Ultra-LD Mk.3 135W/ch stereo amplifier

Completing the wiring & making adjustments

Last month, we introduced our new Ultra-LD Mk.3 135W Stereo Amplifier and described the initial assembly details. In Pt.2 this month, we complete the assembly and describe the adjustment procedure for the power amplifier modules & the remote control.

WE LEFT OFF last month with all the modules mounted in position, except for the two Ultra-LD Mk.3 power amplifier modules. We also described the transformer mounting.

Once the transformer is in place, remove the adjacent side panel of the case by undoing the five self-tapping screws. Be careful during this procedure – the screws will initially be tight and one slip with the screwdriver is all it takes the leave an unsightly mark on the panel. Placing several layers of masking tape around the screw heads while you undo them is a worthwhile insurance policy here.

The next step is to run the 230VAC wiring. This wiring must be installed in a professional manner with all connections securely crimped and insulated.

Removing the side panel gives you good access to the chassis to install the mains wiring. This involves crimping a number of fully-insulated spade connectors onto various leads and it's important to use a ratchet-driven crimping tool for this job (see panel last month). After crimping, you must also check that each connection is secure and that all wire strands are inside the connector – something that's particularly important with mains wiring.

Obtaining A Shielded Power Transformer

Last month, we indicated that the power transformer supplied with kits would come with an integral flux band. However, it transpires that Altronics will be supplying a stock transformer which doesn't have this flux band, although this will still give quite good performance. For optimum signal-to-noise ratio, you can either fit this transformer with a copper strap or you can purchase a shielded transformer from either Harbuch Electronics or from Dyne Industries (see panel later in this article for details).

Pt.2: By GREG SWAIN

Begin by routing the blue and brown primary leads around the rear of the transformer and securing them with several cable ties (see photos & Fig.1 in Pt.1). The blue primary lead can then be trimmed to length (about 225mm), stripped of 5mm of insulation and terminated in a fully-insulated spade connector.

If you want to be doubly-fussy here, it's a good idea to cut a 17mm length of 5mm-diameter heatshrink and slip it over the blue lead before crimping on the connector. The heatshrink can then be slid over the rear section of the connector and shrunk down using a hot-air gun (but take it easy with the heat; gently does it).

This connector can now by plugged into the Neutral terminal on the back of the IEC connector. That done, fit another cable tie to secure both primary leads close to the end of the heatshrink.

Next, cut a 450mm length of brown 32/0.20mm mains-rated cable and terminate one end in another fully-insulated spade connector (and again add the heatshrink). Plug this into the Active terminal on the IEC connector, then feed both this lead and the brown transformer primary lead down a 360mm-length of 5mm-diameter heatshrink.

That done, adjust the heatshrink so that it is about 20mm from the end of the fully-insulated spade connector and apply some gentle heat from a hot-air gun to shrink it down. Push the leads and the heatshrink down flat against the chassis as you do this, so that the leads sit side by side.

This not only keeps the leads together but also double-insulates them where they run around the mains transformer and under the righthand power amplifier module, to keep everything nice and safe.

The switch end of this cable should now be pushed through a rubber insulation boot (eg, Altronics H1472), after which the individual leads can be fitted with fully-insulated spade connectors. Once again, slip a 17mm length of 5mm heatshrink over each lead before crimping on the connector, then push the heatshrink into position over the end of the connector and shrink it down.

That done, secure the mains wiring to the floor of the chassis using four 5mm P-clamps but leave the P-clamp nearest to the power switch out for the time being. Orientate the P-clamps that are fitted at this stage as shown in Fig.1 (and the photo on page 63) and secure them using M4 x 10mm machine screws, flat washers and nuts.

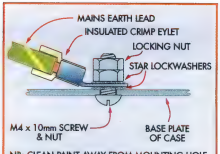


Fig.6: the Earth lead from the IEC connector is secured to the case via an insulated crimp eyelet as shown here. The top nut serves as a lock-nut, so that the assembly cannot come loose. Make sure that the crimp eyelet makes good electrical contact with the case.

Important: as with the audio input cable, you must also install two M4 flat washers under the head of the screw that secures the P-clamp under the power amplifier module. **This avoids the possibility of shorting the end of this screw to the underside of the amplifier.**

Finally, you can complete the mains wiring by installing the main green/yellow Earth lead prepared earlier. This plugs into the Earth terminal of the IEC connector, while the other (eyelet) end is bolted to the main chassis earth point using an M4 x 10mm machine screw, two star washers and two nuts – see Fig.6 above.

The second nut on top locks the assembly into position and ensures that the assembly cannot possibly come loose.

Secondary wiring

Now for the low-voltage secondary wiring. We'll start with the two 40V AC windings which involves the four leads (orange, black, white & red on the prototype) closest to the primary leads.

The first step is to tie the two adja-

WARNING! HIGH VOLTAGE

High AC and DC voltages are present in this circuit. In particular, mains voltages (230V AC) are present on the IEC socket and the primary side of the transformer (including the wiring to the power switch). In addition, the transformer secondary provides an 80V AC output (2 x 40V AC centre-tapped) and the amplifier power supply rails total 114V DC. **Do not touch any part of the amplifier circuitry when power is applied otherwise you could get a severe electric shock.**

The two LEDs on the power supply board indicate when power is present. If they are lit, the power supply and amplifier boards are potentially dangerous.

Parts List: Ultra-LD Mk.3 Stereo Amplifier

1 custom pre-punched steel case with screened front & rear panels
1 32mm black aluminium knob with grub screw (Altronics H 6236)
1 300VA toroidal transformer with two 40VAC windings and two 15VAC 7.5A windings (brown primary lead must be 620mm long to reach the mains switch; blue primary lead must be 240mm long to reach IEC socket)
1 35A 400V chassis-mount bridge rectifier (Altronics Z 0091)
1 SPST 10A 250VAC rocker switch (Altronics S 3224)
1 chassis-mount male IEC socket with fuseholder (Altronics P 8324)
2 M205 3.15A 230VAC slow-blow fuses (one spare) (Altronics S 5657)
1 230VAC 3-pin IEC mains power lead
2 2-way loudspeaker terminal panels (Altronics P 2016)
2 6.3mm double-ended chassis-mount spade lugs (Altronics H 2261)
1 eyelet (ring) connector, 4mm inside diameter (Altronics H 2036A)
19 6.3mm female fully-insulated spade connectors (Altronics H 2001A)
1 piggyback crimp connector (Altronics H 2016A)
4 red right-angle RCA plugs (Altronics P 0169)
4 black right-angle RCA plugs (Altronics P 0170)
13 Nylon P-clamps, 5mm diameter (Altronics H 4201)
1 Nylon P-clamp, 9.5mm diameter (Altronics H 4221)
4 self-adhesive flat cable clamps (Altronics H 4520)
2 self-adhesive cable tie mounts, 12.5mm (Altronics H 4107)
20 small Nylon cable ties
1 1-metre length of 5mm-diameter heatshrink tubing
1 rubber insulation boot to cover mains switch (Altronics H 1472)
Heatsink compound for rectifier

Modules

2 Ultra-LD Mk.3 power amplifier modules (July-August 2011)
1 power supply module (September 2011)
1 loudspeaker protector module (October 2011)
1 stereo preamplifier module (November-December 2011)
1 3-way stereo input selector module plus switch board (November-December 2011)

IDC headers & cables

2 10-pin IDC cable-mounting sockets (Altronics P 5310)
2 14-pin IDC cable-mounting sockets (Altronics P 5314)
1 550mm-length of 10-way IDC cable (Altronics W 2610)
1 650mm-length of 14-way IDC cable (Altronics W 2614)

Wire & cable

1m brown 32/0.20 extra heavy-duty mains-rated hook-up wire (Altronics W 2280)
1m red 32/0.20 extra heavy-duty hook-up wire (Altronics W 2283)
1m black 32/0.20 extra heavy-duty hook-up wire (Altronics W 2284)
250mm 32/0.20 heavy-duty blue hook-up wire (Altronics W 2275)
1m green 32/0.20 extra heavy-duty hook-up wire (Altronics W 2285)
1m figure-8 shielded audio cable (Altronics W 3022)
2m heavy-duty 102/0.12 or 41/0.20 speaker cable (Altronics W 1240)
500mm heavy-duty green/yellow mains-rated cable

Screws, nuts & spacers

50 M3 x 6mm pan-head machine screws
11 M3 x 10mm pan-head machine screws
4 M3 hex nuts
50 M3 flat washers
17 M4 x 10mm panhead screws
21 M4 nuts
1 M4 x 16mm screw (to secure bridge rectifier BR1)
16 M4 flat washers
10 M4 shakeproof washers (for bridge rectifier BR1 and chassis earth points)
14 M3 x 10mm tapped spacers (Altronics H 1216)
4 M3 x 25mm tapped spacers (Altronics H 1233)
3 M2 x 12mm machine screws, nuts and washers (to secure RCA sockets on input selector board to the rear panel)
6 6g x 12mm countersink self-tapping screws (to secure IEC connector and loudspeaker terminal panels)

cent centre leads together using a couple of cable ties. These leads are then trimmed to length (don't cut them too short), after which you remove about 5mm of the spaghetti insulation from the ends. The enamel insulation must then be scraped away from the ends, after which they are lightly soldered together and terminated in a piggyback quick connector (Altronics Cat. H2016A) to form the centre tap.

This centre-tap connector is now plugged into the CT terminal on the power supply PCB. The earth lead prepared earlier is then fitted between the remaining piggyback terminal and the relevant chassis quick connector.

The outer 40V AC leads can now be trimmed, fitted with spade connectors and plugged into the AC terminals of the bridge rectifier. Use a couple of extra cable ties to bind these to the centre-tap leads.

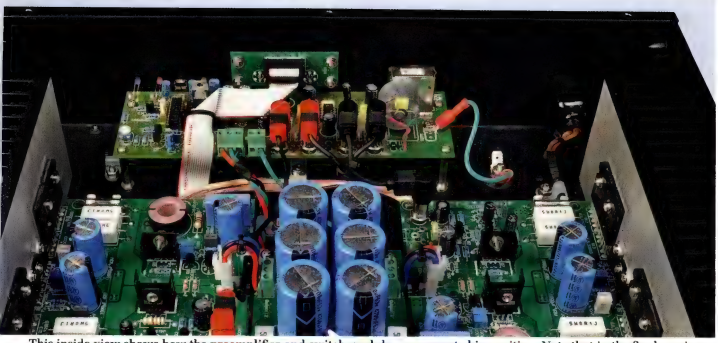
The two 15V AC secondary windings were similarly colour coded on the supplied prototype transfomer. As shown in Fig.1 last month, these leads are terminated in a 3-way screw terminal block on the power supply module, with the central black and white leads again forming the centre tap.

Begin by trimming these leads to length, then remove 5mm of insulation from the ends, scrape away the enamel and lightly solder them together before securing them in the screw-terminal block. The outer 15V AC leads can then be routed alongside the centre-tap leads, trimmed and secured to their relevant screw terminals.

Cable ties can then be used to secure the four leads together.

12V windings & a nasty trap

Our prototype transformer also



This inside view shows how the preamplifier and switch modules are mounted in position. Note that in the final version, an earth lead is also run from the base of the chassis to a spade connector on the front panel (see Fig.1 last month).

came with two grey 12V tappings, which aren't used here. If present, these leads can be shortened to 30-35mm and covered in heatshrink.

However, there's a nasty trap here. Inside each length of grey spaghetti insulation are two enamel-covered leads. In each case, the ends of these two leads must be stripped of enamel and soldered together.

If you don't do that, the 15V windings will be open circuit. That's because the 12V windings form part of the 15V windings, so failing to reconnect the wires inside each grey length of insulation renders the 15V windings inoperative.

DO NOT under any circumstances connect the wires in one grey lead to the wires in the other grey lead.

The best way to deal with these 12V leads is to cut them to unequal lengths, then join the two wires in each individual lead. These wires can then be insulated with some 1.5mm-diameter heatshrink, after which you can sleeve both leads together with some 5mm-diameter heatshrink (see photo below).

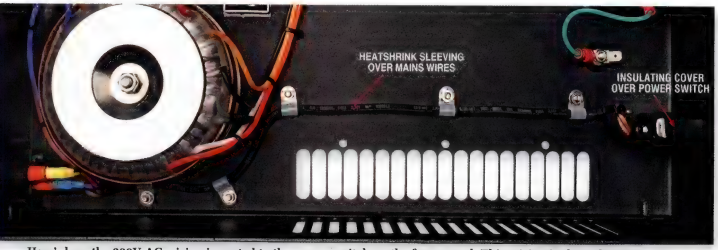
Be gentle with the heat – the spaghetti insulation on the grey leads (and on adjacent leads) is easily damaged.

You can now reattach the side to the chassis. Be careful when installing the self-tapping screw on the bottom edge at the rear – it must be well clear of the mains wiring.

Mounting the amplifiers

Before installing the two power amplifier modules, it's first necessary to solder the two loudspeaker cables to their output pads on the underside of each PCB – see photo on page 65. As explained in the panel accompanying this photo, this is necessary to minimise distortion.

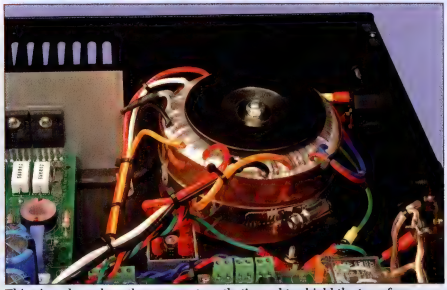
The power amplifiers can now be mounted in the chassis. To do that, first turn the chassis upside down and check that the powder coating has been scraped away from around the



Here's how the 230V AC wiring is routed to the power switch on the front panel. This wiring is sleeved in 5mm-diameter heatshrink over most of its length and is secured to the floor of the chassis using Nylon P-clips. Note the rubber insulating boot (or cover) that's pushed over the mains switch.

Shielding The Toroidal Transformer

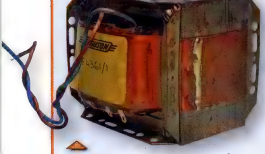
By Leo Simpson



This view shows how the copper strap that's used to shield the transformer is held in place using using a 90-120mm stainless-steel pipe clamp.

THE TOROIDAL transformer used in the Ultra-LD Mk.3 amplifier was initially unshielded. However, during testing, we found that the amount of hum and rectifier buzz from the windings was enough to cause some noise and hum in the output, albeit at a signal-to-noise (S/N) ratio of better than 100dB (which is still quite good). It was worse in the left channel which has its amplifier module closer to the transformer than the right channel.

To fix this problem, we adopted a technique that was commonly employed in E-I transformers where it was common to wrap a copper strap in close proximity around the windings – see photo. The copper strap is referred to as a "flux band" and it effectively provides a shorted turn to all the leakage flux produced by the core of transformer.



Above: it was quite common for Australian-made E-I transformers to be fitted with a copper strap to minimise the leakage flux.

With E-I transformers (E & I refer to the shape of the stamped steel laminations), the copper strap is wrapped around the core and the outside of the windings and is soldered to produce a low resistance shorted turn.

While we can fit a copper strap around the outside of a toroidal transformer, it is not possible to solder it, as to do so would damage the outside insulation. So to hold the copper strap tightly in place, we used a 90-120mm stainless steel pipe clamp with a worm-screw adjustment. These can be obtained from plumbing suppliers.

The strap was cut from a sheet of 0.5mm-thick copper (obtained from a scrap metal dealer) to give a strap measuring 450 x 45mm. This is easily done if you have a guillotine but if you are careful you can do it with a pair of large tin-snips.

The steps are as follows. Make sure that the copper sheet is as free from blemishes as possible. Any small dimples or ripples can be (gently) removed with a rubber mallet or soft-face hammer. Then polish the area to be cut off using Brasso or similar metal polish. Polish it on both sides to a bright shine.

Hopefully, the sheet has one straight edge which can then be used for marking out the dimensions of the strap. So you need to scribe a line on the sheet on the copper, 45mm from the straight edge.

Now there are several tricks to using tin-snips to make precision straight-line cuts. If at all possible, do a trial run on a piece of thin steel or aluminium sheet. When cutting with tin-snips, depending on whether they are left-hand or right-hand, you will find that one side of the cut material naturally curves up or down. You use this natural curvature to produce the copper strap – in our case we do want it curved.

Proceed with your cut very slowly – don't hurry it otherwise you are sure to get a crooked cut. Keep going until you have a strap more than 450mm long. Then scribe lines at right angles to produce squared-off ends of the strap. Again, cut these carefully and then nip of the corners.

Do not try to straighten out the curve of the strap. If you have finger-marks on the copper surface, clean them off thoroughly.

Now we want to bend the strap in a smooth circle so it will wrap smoothly around the outside of the transformer and produce an overlap of about 100mm. The important point about this is that you need a series of different circular formers, starting large and coming down to about 90mm diameter or so. We used a number of different sized paint tins and finished with a length of 90mm plastic storm-water pipe.

The point about using different sized pain tins is that if you use too small a former to start with, you run the risk of putting kinks in the strap.

Once you have finished with the smallest former, you will find that the resulting circular strap has a diameter of around 100 to 120mm and will be slightly springy. Good! That makes it a little easier to fit around the transformer. It can then be locked in place with the stainless steel pipe clamp referred to above.

In our case, we fitted the copper strap to the transformer after it had been wired in place, which made it quite tricky. The copper strap improved the signal-to-noise ratio from just over -100dB to -111dB in the right channel and to -107dB in the left channel which is excellent.

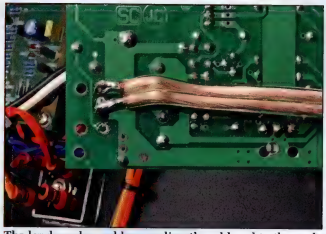
Some constructors may want to take the risk of not fitting the transformer with a copper strap initially. If they then decide that their finished amplifier is insufficiently quiet, they can still fit the strap.

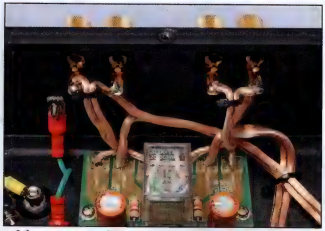
On the other hand, if you feel that you could not produce a neat and effective copper band, then you could purchase a shielded toroidal transformer from either of two suppliers:

(1) Harbuch Electronics, phone (02) 9476 5854, **www.harbuch.com.au**

(2) Dyne Industries, phone (03) 9720 7233, **www.dyne.com.au**

Solder The Loudspeaker Cable Connections For Low Distortion





The loudspeaker cables are directly soldered to the underside of the power amplifier modules (left) and also to the loudspeaker protector module (right) to achieve the lowest possible distortion figures.

As originally described in July 2011, the Ultra-LD Mk.3 Amplifier Module used a Molex Mini-fit Jr 4-pin socket as a loudspeaker connector (CON3). However, when we came to test the fully-assembled stereo amplifier, we found that the metal-to-metal contacts in these connectors were a significant cause of distortion. A similar effect was found with the spade connectors on the loudspeaker protection module.

The overall effect was sufficient to double the distortion readings of the complete amplifier. Accordingly, the final assembly eliminates the connectors on the power amplifier modules and the loudspeaker leads are directly soldered to the output terminals of the power amplifier modules instead. Similarly, the push-on (female) spade connectors have been eliminated from the loudspeaker cables that go to the loudspeaker protection module and all connections are directly soldered to the PCB (ie, the quick connect male spade terminals are eliminated).

As far as the original Ultra-LD Mk.3 amplifier and loudspeaker protector modules are concerned, the original loudspeaker connection arrangement can be retained where extremely low distortion is not critical, eg, in a guitar amplifier.

holes for the six screws that are used to secure the heatsinks.

That done, secure each module to the chassis using three M3 x 10mm screws which go into the heatsinks, plus a lock washer under the head of each screw. The lock washers bite into the bare metal and ensure that the heatsinks are solidly earthed.

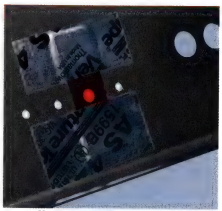
Don't over-tighten these screws – it's all too easy to strip the threads inside the aluminium heatsinks if you do.

Be sure to route the loudspeaker cables as shown in Fig.1 when installing the power amplifier modules. The cable for the right channel amplifier runs directly back under the PCB towards the rear of the chassis. By contrast, the loudspeaker cable from the left channel amplifier runs back under the board towards the front of the chassis. It then loops around and runs back under the right channel amplifier.

Once the amplifier modules are in position, secure their spacers on the edges nearest the power supply to the chassis using M3 x 6mm screws. Temporarily loosen off the heatsink screws to get everything to line up if necessary.

The free ends of the loudspeaker cable can now be soldered to the loudspeaker protector module. If quick connect terminals have already been soldered on this board, then you can solder the loudpeaker cables directly to them. If not, you can temporarily remove the loudspeaker protector and drill holes in the PCB so that the loudspeaker cables can be directly soldered to the relevant copper pads.

Don't use bolt-on quick connectors on the loudspeaker protector board - they will only cause distortion.



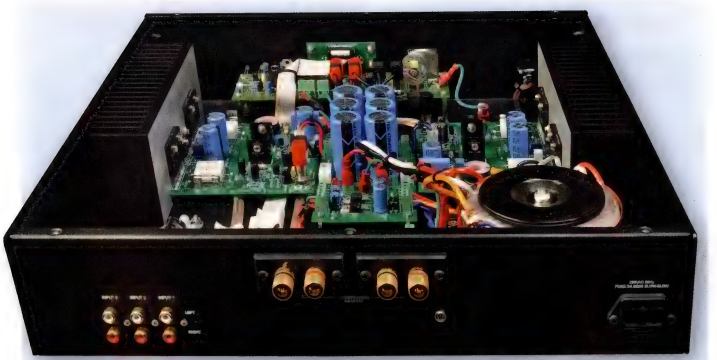
A small piece of red film is attached to the inside of the front panel, over the hole for the infrared receiver.

Connecting the RCA cables

The RCA audio cables can now be plugged into the preamplifier and to the power amplifier. Note that the RCA cable to the right-channel power amplifier is routed via a P-clamp that's secured to one corner of the power supply module. A short piece of aerated foam wrapped around the cable will stop it from moving.

You will have to remove the existing M3 x 6mm mounting screw at this point and substitute an M3 x 10mm screw when the P-clamp is installed. The short RCA cable to the left-channel amplifier is secured to its adjacent audio input cable using a cable tie so that it cannot come loose and contact high voltage wiring.

Do not plug the supply connectors into the power amplifier modules at



The rear panel of the amplifier carries the three pairs of RCA input sockets, the loudspeaker terminals and the IEC connector. Be sure to use self-tapping screws to secure the IEC connector, so that they are earthed to the chassis.

this stage. That step comes later, after you have checked out the power supply voltages and the operation of the loudspeaker protector.

Mounting the front panel

Now for the final assembly. Snap the mains switch into its front-panel cut-out with its outside terminal to the top, then attach a small piece of red film to the inside of the panel over the hole for the infrared receiver. This can be cut into a strip and secured with short strips of duct tape at either end (see photo) or you can use silicone.

The front panel can now be slid into position and secured along its bottom edge using the supplied countersink machine screws. The mains leads can then be connected to the switch and the earth lead connected between the lug on the rear of the front panel and the adjacent chassis earth point – see Fig.1 in Pt.1.

Note: this earth connection is not present in the prototype. We decided to add it after we had the prototype metalwork made, to make it easier to securely earth the front panel rather than just rely on the machine screws that secure the panel to the chassis. Do not omit this earth connection.

Once the switch wiring is complete, slide the rubber insulating boot over the switch and secure it in place by fitting a cable tie to the switch wires close to where they enter the boot. The remaining (fifth) P-clamp can then be used to secure the switch wiring to the chassis, before it disappears under the lefthand power amplifier module.

Initial checks

There are a few things to check before connecting the loudspeaker leads to the speaker protector or even plugging in a mains cord and switching on:

CHECK 1: Check the 230V wiring to the IEC socket, mains transformer and mains switch. In particular, the female spade connectors should all be tightly crimped, the connectors must be fully insulated and there must be no wire strands outside these connectors.

In addition, all spade connectors must be a tight fit onto their lugs, especially at the IEC socket, the mains switch and the bridge rectifier. Retension any connectors that slide on too easily.

CHECK 2: Check that BR1's positive and negative terminals connect to the correct terminals on the power supply board.

CHECK 3: Check that all the electrolytic capacitors on the power supply board are installed with the correct polarity. These things have a nasty habit of exploding if they're in the wrong way around. The same goes for other electrolytics across the supply rails on the other modules.

In fact, it's a good idea to wear safety glasses when switching on for the first time, in case you do have a capacitor in the wrong way around or you accidentally reverse the polarity to the power supply module. Exploding capacitors and eyeballs don't mix too well!

Better still, fit the lid to the case before initially applying power to the amplifier – see Step 5 below.

CHECK 4: Use a multimeter to confirm that all the chassis panels are correctly earthed. Do that by checking for continuity between the earth terminal of the IEC socket and each of the panels in turn. Remove some of the powder coating from an inside surface of each panel to make this check, if necessary.

Similarly, check that the heatsinks are earthed to the chassis and that all external screw heads are earthed.

CHECK 5: Use a multimeter to confirm that the heatsink transistors (Q10-Q16) on each amplifier module are electrically isolated from the heatsink itself (see the article in the August 2011 issue).

Test & adjustment

The basic procedure here is to test the output rails from the power supply module before applying power to the remaining modules.

Adjusting The Quiescent Current Through The Power Amplifiers

The quiescent current flowing in the output stage of each power amplifier is initially adjusted by installing 68Ω 5W resistors in place of the fuses. The voltage across one resistor is then monitored and trimpot VR1 adjusted for a reading of 9.5V – equivalent to a quiescent current of 140mA.

The easiest way to connect the resistors is to "blow" the fuse wires in a couple of spare M205 fuses, then drill holes in the end caps and solder the resistors in place as shown. The original fuses can then be removed and the "modified" fuses clipped into place – see photo below.

Here's the step-by-step procedure:

STEP 1: Disconnect the supply leads to the preamplifier and the loudspeaker protector (do this at the power supply module).

STEP 2: Check that the DC supplies to the power amplifier modules are unplugged.

STEP 3: Remove the fuses from the power amplifier modules.

STEP 4: Slide out the fuse drawer at the bottom of the IEC connector, fit a 3A slow-blow fuse into the plastic lugs at the bottom of the drawer and slide the drawer back into position.

STEP 5: Connect an IEC power cord to the amplifier and use a multimeter to confirm continuity between the earth pin of the plug and the chassis earth. That done, plug the cord into a mains socket and switch on.

Warning: don't go poking around the rear of the IEC socket and the front-panel switch when the device is plugged into the mains. Most of the terminals will be at 230V AC!

Note also that high DC and AC voltages are present in

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Selecting The Mode & Programming The Remote

As stated in the text, it's necessary to program the universal remote control correctly. By default, the microcontroller's RC5 code is set to TV but SAT1 or SAT2 can also be selected. Just press and hold button S1 on the Switch Board during power-up for SAT1 or button S2 for SAT2. Pressing S3 at power-up reverts to TV mode.

Once you've chosen the mode or "device", the correct code must be programmed into the remote. This involves selecting TV, SAT1 or SAT2 on the remote (to agree with the microcontroller set-up) and then programming in a three or 4-digit number for a Philips device. That's because most Philips devices (but not all) rely on the RC5 code standard.

Most universal remote controls can be used, including the Altronics A1012 ($19.95). For this remote, use a code of 023 or 089 for TV mode, 242 for SAT1 or 035 for SAT2.

In the case of other universal remotes, it's just a matter of testing the various codes until you find one that works. There are usually no more than 15 codes (and usually a lot less) listed for each Philips device, so it shouldn't take long to find the correct one.

Note that some codes may only partially work, eg, they might control the volume but not the input selection. In that case, try a different code. In addition, some remotes may only work in one mode (eg, TV but not SAT).

The unit will work with most universal remotes including the Altronics A1012.

this circuit. In particular, the 40VAC transformer secondaries are connected together to provide a total of 80VAC to the bridge rectifier, while the amplifier power supply rails total 114V DC.

Do not touch any of this high-voltage circuitry (including the fuses on the power amplifiers) while power is applied – see warning panel.

STEP 6: Use a multimeter to check the various DC outputs on the supply module. There should be close to ±57V on CON1 & CON2, ±15V on CON3 and +20V on CON6 (all with respect to 0V). In addition, you should be able to measure 30VAC on CON5.

If you don't get the correct voltages, switch off immediately and check for wiring and component errors.

STEP 7: If the power supply checks out, switch off, wait until the LEDs on the supply board go out, then reconnect the AC and DC supplies to the loudspeaker protector module. Apply power and check that the relay turns on after about 5s. If it does, temporarily short the terminals on CON3 – the relay should immediately switch off.

Similarly, the relay should immediately switch off if you disconnect one of the AC leads to CON2 (note: do not temporarily install a link between CON1 & CON2 for testing, as described in the October 2011 article, if the 30V AC leads are connected to CON2).

Now check that that the relay switches off if you connect a 3V (eg, 2 x 1.5V cells in series) or 9V battery (either way around) between the LSPKIN+ terminal and the ground (-) terminal of CON1. Repeat this test for the RSPKIN+ terminal, then reverse the battery polarity and perform both tests again.

STEP 8: Switch off, wait until the power supply LEDs to go out and reconnect the ±15V supply wiring from the preamplifier. Reapply power and check that the blue front-panel power LED lights.

One of the blue switch LEDs should also light. Check that you can manually select the inputs by pressing the input switches.

STEP 9: Set up and test the remote control functions for the preamp, as detailed in the December 2011 issue. That done, adjust trimpot VR2 as described, so that the muting function operates correctly.

The Altronics A1012 universal remote shown above is ideal for use with this unit. Note that it must be programmed by choosing a mode (TV, SAT1 or SAT2) and entering in the corresponding code – see the above panel.

STEP 10: Switch off again, wait for the supply LEDs to go out, then connect the ±57V DC supply for the right channel power amplifier. Check that the on-board fuses have been removed.

STEP 11: Connect 68Ω 5W resistors across the fuse clips as described in the September 2011 article on the Ultra-LD Mk.3 amplifier module. That done, adjust the quiescent current through the output stage by following steps 1-11 in that article.

STEP 12: Remove the safety resistors and install the fuses for that module.

STEP 13: Repeat the last three steps for the left-channel power amplifier. Refer to the troubleshooting procedure in the September 2011 article if you strike problems.

In particular, note that the DC offset voltage across each pair of speaker terminals should be less that ±50mV with power applied.

Listening test

That's it – your new, high-performance Ultra-LD Mk.3 Stereo Amplifier is ready for action.

Connect it to a CD and/or DVD player and a pair of loudspeakers, switch on and listen with your ear close to one of the loudspeakers but without any music playing. Even with the volume at full level, there should only be a barely perceptible "hiss" from the speaker (and that's in a quiet room).

Now turn the volume control back to a low level, select the appropriate input and play some music. You should be rewarded with clean, undistorted sound and the amplifier should have plenty of power when you wind the wick up.

Finally, check that you can vary the volume and select inputs using the remote control. The yellow acknowledge (ACK) LED should flash each time a remote control button is pressed, while the yellow LED comes on when the sound is muted.

That completes the assembly. Next month, we'll publish the specifications and do a comparison between this new amplifier and the 20W Class-A Stereo Amplifier described from May-September 2007. SC

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See Review April 2011

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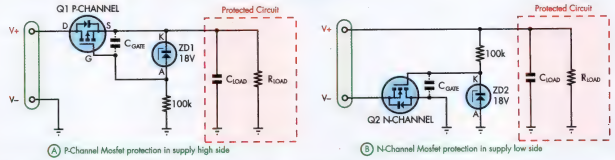

(A) P-Channel Mosfet protection in supply high side

(B) N-Channel Mosfet protection in supply low side

Using Mosfets for reverse polarity protection

Most SILICON CHIP projects contain some form of supply reverse polarity protection, so the circuit is not damaged if the supply connections are accidentally reversed (eg, battery inserted backwards or plugpack incorrectly wired).

Traditionally, a standard diode is connected in series with the positive supply terminal. But lately we have produced designs where a Mosfet is used instead: the 12V Mini Stereo Amplifier (May 2010), the LED Dazzler (February 2011) and the MiniSwitcher (February 2012). This has confused some readers, mainly because the configuration used is unusual for a Mosfet.

The problem with a traditional series diode is that it reduces the supply voltage to the protected circuit by 0.6-1.1V. In most cases, this isn't a problem but sometimes it can be a major disadvantage.

For example, in battery-operated circuits this can effectively reduce battery life. If a circuit running from two AA cells can operate down to 1.8V, a polarity protection diode increases the cut-off threshold to around 2.4V (1.8V + 0.6V). It will therefore stop working before alkaline cells are fully discharged and it may not work at all with NiMH or Nicad cells which are only about 1.2V each when fully charged.

A series diode is also a problem for power circuits which draw a lot of current. A large diode is required and dissipation can be high (many watts), significantly reducing circuit efficiency and presenting a problem in a sealed case that may be exposed to high ambient temperatures.

If a Schottky diode is used instead of a standard silicon diode, the voltage loss is lower (0.1-0.6V) which is better but it doesn't eliminate the problems. At very high currents (10A+), dissipation is still significant.

By contrast, the voltage loss when using a Mosfet can be negligible (less than 5mV at 1A) with practically no dissipation and little reduction in efficiency compared to a circuit with no reverse polarity protection.

Circuit (A) shows how a P-channel Mosfet is inserted in the high side of the supply circuit, similar to a regular diode. To understand this circuit it is important to understand how Mosfets work.

In their discrete form (ie, not in an integrated circuit), virtually all Mosfets have a parasitic "body diode" between the drain and source terminals. The Mosfet's conductive channel is in parallel with the body diode and this can be thought of as a resistance which is controlled by the gate voltage (relative to the source terminal voltage).

For a P-channel Mosfet, the channel resistance is high when the gate voltage is close to or above the source voltage. If the gate is pulled negative relative to the source, by at least a few volts, the channel resistance drops dramatically. The gate-source voltage at which significant channel current flows is known as the gate threshold voltage and is usually around 3V, although newer Mosfets can have much lower thresholds.

The maximum gate-source voltage must be limited or else the Mosfet will be damaged. A typical limit is ±20V although newer Mosfets with lower gate thresholds often have a

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lower maximum limit (eg, ±12V).

When the gate voltage is well beyond the threshold, the resulting channel resistance figure is called the on-resistance (more properly, static drain-source on-resistance or $R_{DS}(on)$). For high-current applications, lower $R_{DS}(on)$ is generally better as this minimises I^2R conduction losses and thus dissipation.

Now, while the body diode determines how a Mosfet must be orientated when used as a switch (so the diode is reverse-biased when it is off), in fact the channel can conduct current in either direction. So when the Mosfet is on, the body diode is effectively shorted out and is therefore irrelevant.

Consider what happens in circuit (A) when power is first applied. All capacitors are discharged, including Q1's internal gate capacitance C_{GATE} (which is inherent to the Mosfet), so its gate-source voltage is zero and the channel is not conducting. Initially then, current flows into the load via Q1's body diode and is subject to its forward voltage drop.

As C_{LOAD} charges, the voltage across the load increases and so C_{GATE} begins to charge via the 100kΩ resistor. Together these form an RC low-pass filter and the response of this filter determines how long it takes for Q1 to turn on. Depending on the supply impedance and the size of the load capacitance, C_{LOAD}'s charge time may provide an additional delay.

Eventually Q1's gate-source voltage reaches the threshold and its channel conducts, shunting current around the body diode and thus reducing the voltage across Q1. Very quickly, this drops to a value limited only by Q1's $R_{DS}(on)$ figure and the load current (V = IR).

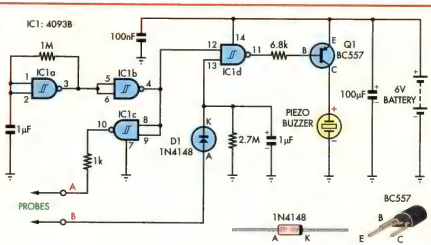
But if the supply is connected with the wrong polarity, Q1's gate is pulled above its source voltage rather than below and so the channel will not conduct. Also, in this case, the body diode is reverse-biased so only a very small amount of current can flow, via the 100kΩ resistor.

Note that Mosfet Q1's maximum drain-source voltage rating must be sufficient to avoid reverse breakdown in this situation. In applications where the normal supply voltage can exceed Q1's rated maximum gate-source voltage, zener diode ZD1 protects it from damage. If the supply voltage is over 18V, ZD1 conducts, limiting the gate voltage to a safe level and the 100kΩ resistor limits the current flow in this situation.

An alternative configuration is shown as circuit (B), this time using an N-channel Mosfet rather than a P-channel device. As a result, the circuit polarity is reversed but it is otherwise identical in operation to (A).

The advantage is that N-channel Mosfets have a lower $R_{DS}(on)$ compared to P-channel Mosfets of similar geometry. However, the voltage loss across Q2 (however small) shifts the protected circuit's ground potential relative to the supply and this isn't always desirable – especially if it's possible for the two grounds to be joined elsewhere (eg, via signal cables).

Nicholas Vinen,
Silicon Chip.



Simple water level alarm

This battery-operated alarm circuit provides an audible warning when the water level rises past a certain point. For example, it could be used in the bilge of a boat or in a basement. Its low current drain means the four AA cells will last for a long time. It is based around a CD4093 quad Schmitt-trigger NAND gate (IC1) and little else.

IC1a is wired with its input pins 1 & 2 tied together (ie, as an inverter) and forms an astable oscillator that runs at around 1Hz. Its square-wave output is fed to IC1b which buffers and inverts the signal to drive inverter IC1c. Its output is connected to probe A via a 1kΩ resistor.

The two probes are electrically insulated but placed in proximity in the vessel to be monitored. When water covers them both, it forms a circuit between them, with a certain amount of resistance (depending on proximity, salt content and other factors).

Current from IC1c's output then flows via the water and diode D1 to charge the 1µF capacitor at pin 13 of IC1d. This capacitor is slowly discharged by a parallel 2.7MΩ resistor which prevents false triggering.

With both probes submerged, the pin 13 input of IC1d gates the 1Hz signal at its pin 12 through to PNP transistor Q1 which drives the piezo buzzer which has an internal oscillator. Hence the buzzer emits chirps once every second until the alarm is turned off or the water level drops below the probes.

Michael Azzopardi,
Deer Park, Vic. ($40)

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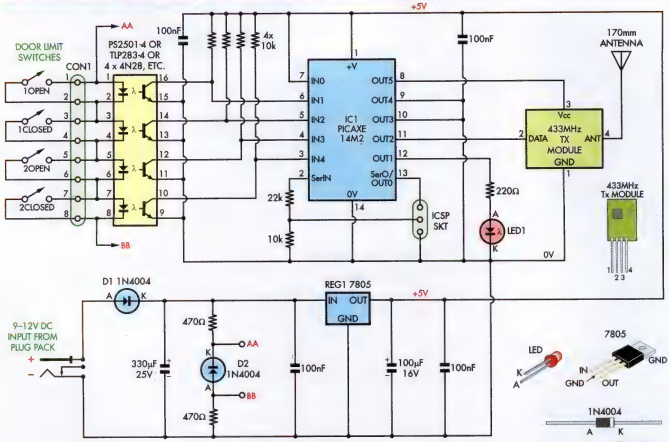


433MHz garage door position monitor

This unit uses a 433MHz wireless link to remotely monitor two garage doors, to indicate whether they are open, closed or in mid-travel.

In operation, limit switches are used to detect the open and closed position of each door. The limit switches can be either reed or micro-switches and are mounted on the walls adjacent to the doors. Pressing the RUN switch on the receiver displays the door positions for 15 seconds. Both the transmitter and receiver use PICAXE14M2 microcontrollers to drive 433MHz modules.

The transmitter circuit is continuously powered from a 9V–12V DC plugpack which feeds 5V regulator REG1. Each limit switch is connected in parallel with the internal LED of an associated optocoupler. The four optocouplers for the two doors are connected in series (current loop style) with two 470Ω resistors across the unregulated DC supply to REG1.

Closing a limit switch diverts the loop current from the internal LED of the associated optocoupler, turning its transistor output off and thereby allowing one of the micro's inputs to be pulled high by a 10kΩ resistor.

The door status information is transmitted once each second using the "rfout" command. This requires a high level from OUT5 (pin 8) to power the V_{CC} pin on the transmitter module. With the transmitter active, OUT2 (pin 11 of IC1) sends eight bytes of Manchester-encoded data to the DATA pin on the transmitter module. This consists of four door status bytes followed by four PIN code bytes. For each eight bytes of data sent, OUT1 (pin 12) flashes LED1 to show the transmitter is working. OUT5 then goes low, to power off the transmitter module.

The receiver circuit is powered by a 6V battery. This is fed via diode D1 and PNP transistor Q1. The 433MHz receiver module and PICAXE micro are normally off, waiting for the RUN pushbutton (S1) to be pressed. This turns transistor Q1 on, to feed power to the receiver and micro. The PICAXE micro then sets its pin 7 high, turning on transistor Q2 and keeping Q1 on, so that the RUN button can be released. The micro keeps the transistors powered on for 15 seconds, which allows receiver data to be processed and the six door status LEDs to show the positions of the doors. (Always wait for the door status LEDs to turn on before releasing the RUN pushbutton).

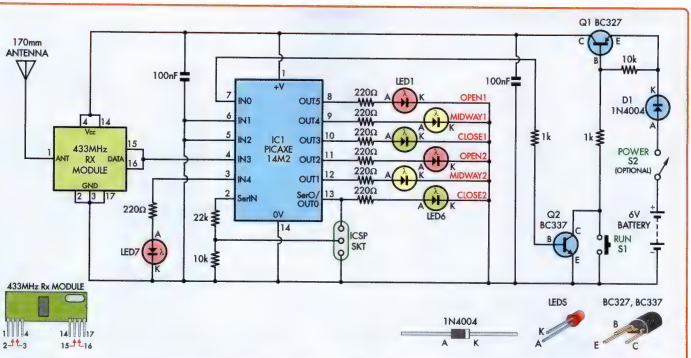
Ian Robertson is this month's winner of a $150 gift voucher from Hare & Forbes

The door status and the PIN code bytes from the transmitter are processed using the "rfin" command and after first checking the PIN code, the relevant door status LEDs are turned on to show whether each door is fully open, fully closed or midway. Also pin 3 flashes LED7 to show data is being received.

Using a 1-second data rate allows other equipment to share the same frequency but adds a short delay to the door status LEDs. For the receiver to operate properly, you must use a RUN pushbutton with a good quality "snap action" mechanism.

The prototype used 433MHz transmitter and receiver modules from Jaycar, Cat. ZW-3100 and ZW3102, respectively.

They each require a basic antenna



and a 170mm length of hook-up wire is adequate. The receiver will only operate successfully if located several metres away from the transmitter, otherwise the antenna input circuit may be overloaded.

The transmitter and receiver circuits include a 3-pin programming socket, allowing the same program "gdmonitor_14m2.bas" to be downloaded into both units. The set-up routine checks the voltage level at pin 7 at start-up and selects the correct sub-program to run. The program listing includes additional comments and notes about operation.

Ian Robertson,
Engadine, NSW.

Note: the software (gdmonitor_14m2.bas) can be downloaded from the SILICON CHIP website.

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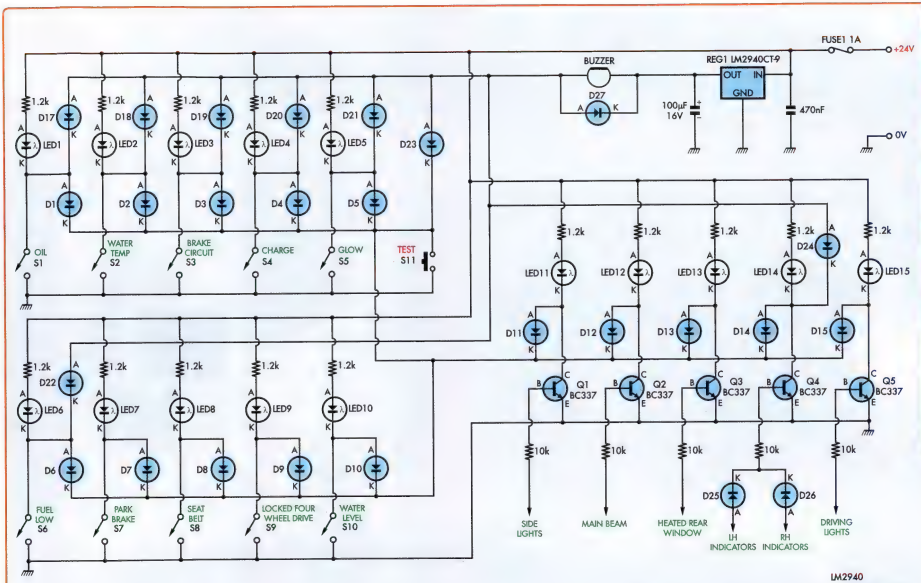

NOTE: ALL LEDS ARE 5mm WHITE, CLEAR (JAYCAR ZD-0190 OR SIMILAR)
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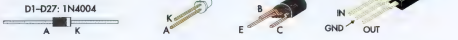

12/24V vehicle instrument panel

This instrument panel was designed for use in a vehicle converted from 12V to 24V, to suit a 4-cylinder diesel engine which was fitted in place of the original V8 petrol engine. It was decided that fitting a new panel was better than changing all the 12V lamps to 24V types. This design can also be used with 12V electrical systems; in this case, change the 1.2kΩ 1W resistors to 560Ω 0.5W.

In combination with the sensors throughout the vehicle, it lights LEDs in response to various situations such as the engine being cold, the headlights being switched on, low coolant water level and so on. It also has a buzzer which sounds when a problem occurs and a test pushbutton which allows you to check that the LEDs and buzzer are all working.

While this circuit was designed to suit one particular vehicle, it can easily be adapted for others or to a fixed installation. The white LEDs were placed behind the existing instrument panel, to illuminate the translucent indicator cut-outs in the panel. Many white LEDs have a narrow beam angle and may not illuminate the indicators properly; if so, rub the lenses with fine emery paper to improve the diffusion. Coloured LEDs can be used too.

Switches S1-S10 represent various sensors which conduct when on. These drive the LEDs directly, connecting their cathodes to ground (0V). For the headlights, indicators and rear window heater, the signals are active high. As a result, indicator LEDs11-15 are driven by NPN transistors Q1-Q5 which are in turn driven by the relevant signals via 10kΩ series current-limiting resistors.

The left and right indicator inputs are ORed using diodes D25 and D26, to drive transistor Q4 and LED14 if either the left or right indicators are in use.

The buzzer sounds whenever one of LED1-LED6 or LED14 lights. In each case, if the LED cathode is brought low, current from the buzzer flows through one of diodes D17-D22 or D24. The positive buzzer terminal is driven from +9V, derived from the +24V (or +12V) supply by REG1, a low-dropout linear regulator. Diode D27 prevents any voltage spikes on the regulator output when the buzzer turns off.

When test pushbutton S1 is pressed, current can flow from all LED cathodes to ground via diodes D1-D15 and also from the buzzer via D23.

Ron Groves,
Cooloola Cove, Qld. ($60)

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Monitor & Record Weather Conditions

Providing an instant snapshot readout of conditions, plus the ability to log long term trends via PC. Includes wireless solar powered sensors, base station & software allowing you to log all data direct to your computer. Windows 2000/XP/Vista/7. Requires 3 x AA batteries.

Wireless sensors can be located up to 100m away from screen
Indoor & outdoor temperature
Humidity, barometric pressure
Rainfall, ambient light, UV index
Wind speed & direction

SAVE $30
$139
T 2418

Micron® 80W Digital Soldering Station

An excellent multi purpose soldering iron for service technicians, schools, engineers, R&D, production work etc. Japanese ceramic heating element for long life. 200° to 480°C. 0.8mm tip.

Slimline handle	Burn resistant lead	All metal case

SAVE 10%
$66
M 8996

100W Laptop Power Supply

Old power supply cactus? No problem! Fitted with dual USB outputs. Includes mains lead & 8 tips to suit most laptops. Selectable voltages (15-24VDC), max 6A/100W.

Opus One® 2 x 100W Stereo AM/FM Receiver

A 2691A

SAVE $50
$325

Expand your home audio system to the study or entertainment area. Features five stereo RCA inputs, front panel input for iPod, in-built AM/FM tuner and A/B speaker selection. Includes remote. Size: 430x283x80mm.

Great for mechanics, plumbers and installers

S 8742

SAVE $20
$149

See Inside Walls, Pipes & Conduits...

...with this handheld inspection camera & 2.4" LCD monitor. Great for accessing difficult locations such as wall cavities, ceiling spaces, pipework & industrial machinery. Requires 4xAA batteries for camera. Includes carry case.

SAVE 22%
$45
M 8992

Netbook Power Supply

Ideal replacement for lost/broken supplies. Fitted with USB output. Includes 6 tips & mains lead. 12-20VDC, max 5.4A/75W.

SAVE $20
$199
S 8861

Key Features
MP3 & video USB/SD playback
Photo slideshows
Digital SD & analog tuner
USB stick recording

TV for the Car, Caravan or Boat With HD Tuner.

This new 7" wide format LCD features in-built HD tuner to receive all the latest Freeview channels. USB port is provided for PVR recording of shows. Powered by a internal rechargeable battery, mains plugpack or car accessory socket. Easy to install.

SAVE 22%
$45
D 5507

Great for backups!

USB 3.0 Desktop Hard Drive Dock

The easy way to move data from one drive to another. Suits 2.5" or 3.5" SATA hard drives. Includes power supply, USB3.0 lead & PC backup software.

M 8623A
NEW!
$9.95

Handy Car USB Adaptor

Buy two for $16

Stay charged up on the road! Max output 2A. Suits iPads iPhones etc.

Sunwave® Compact Multi Device Remote

Replaces all the most commonly used functions on your current remotes.

- Powerful 'point and learn' mode
- Combines 6 remotes into 1
- Dimensions: 125 x 55 x 18mm
- Requires 2 x AAA batteries.

SAVE $20
$79
Q 1264

Fine Tune Your Sound System

A useful tool for high end home theatre systems, PA & car audio. This SPL meter measures up to 130dB (1.5dB accuracy). Used widely in the audio industry for ensuring sound levels remain legal. Includes 9V battery.

Buy two for $20

M 8892
NEW!
$12.95

Dual USB Mains Adaptor

With pass through 240V socket so you don't lose an outlet! Great for keeping your phone, tablet or MP3 player charged up.

SAVE 22%
$34
A 0983

Great Value!

SAVE 18%
$49
T 2172

Great Value 129pc Handyman Tool Kit

Great for tackling jobs around the house, on the car, boat or 4WD. To buy individually these tools could set you back over $200! Includes a massive array of tools -hammer, pliers, allen keys, ratchet screwdriver, spirit level, lug crimper & knife. See website for full list.

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PRICE CRASH

On Quality Solar Panels

HALF PRICE!

Genius Power® Pure Sine Wave 3 in 1 Inverters

These state of the art UPS/inverters utilise sophisticated circuitry that includes a battery charger, inverter, solar regulator and automatic bypass switch suitable for a variety of power backup installations - plus, of course, freestanding DC to 230V AC mains power in their own right. For uninterruptible power (UPS) applications, they are designed to be permanently connected to 230/240V grid power, a solar array and battery bank. With mains power failure the UPS load (eg computer system, communications etc) 230V power is provided from the battery bank via the inverter. The control panel provides monitoring for capacity remaining, current and voltage. Plus adjustments for output voltage & frequency.

Worry free remote power!

Huge savings This month only

SAVE $200	SAVE $300	SAVE $400
$899	$1299	$1699
M 8139 800W 12V Input	M 8144 1600W 24V Input	M 8145 2400W 24V Input

TOP SHELF 180 Watt Solar Panels

These superb 180W 24V monocrystalline panels will provide a typical life in excess of 25 years! They are manufactured under strict supervision by a German quality control company.

The results are high efficiency panels of impeccable quality!

Includes:
- Full 25 year output warranty.
- 5 year workmanship warranty.
- Approved by Clean Energy Council.
- VDE® IEC standard certified.
- MC-4 connection fly leads.

Applications:
- UPS battery backup systems
- Remote power 'off grid' installations
- Mobile RV & caravan power backup

N 0180

$399 RRP $699ea

OR 4 UP $349ea

See pages 206-208 of our catalogue for system designs for remote house power, boats & mobile homes

$499 SAVE $200

Hurry, stocks are limited at this price!

Pure Sine Wave 1000W Continuous

Ideal For...
- 4WD's
- Campers
- Service Vans
- Remote power

M 8017 12V Input
M 8018 24V Input

240V Mains Power Anywhere, Anytime!

Efficient 'pure sine wave' design delivers pure AC power. High 3000W surge rating for powering difficult to start loads such as microwaves, computers and televisions. **1000W continuous.** Size: 405 x 320 x 125mm.

These panels can be configured for 12 or 24V battery installations, using an Australian designed GSL® MPPT charger...

96% efficient! Incredible performance

SAVE $16 $210 N 2028 12A

GSL® MPPT Programmable Solar Regulator

Increase bulk charge current from a solar panel by more than 20%! Precision charging modes and reduced noise provides major efficiency advantages over a conventional regulator. Simple 3 wire connection. Auto select for 12V & 24V systems. Offers down to dusk load switching, low voltage disconnect, remote alarm and programming capability. 12A rated. 35x75x100mm.

N 2030 30A N 2036 60A

SAVE $31 $299 SAVE $36 $399

Programmable models also available

High Current GSL® MPPT Solar Chargers

Offering easy 4 wire in-line connection these high efficiency solar regulators can be used with 12V, 24V or 48V solar systems. The MPPT circuitry employed offers up to 20% increased panel efficiency - boosting the amount of power you can get from the sun! The absorption & float charge regime used ensures maximum battery life and performance. Suits vented or sealed lead acid batteries. **See our website for full installation guide.**

SAVE 26% $149 M 8010

Pure sine wave

SAVE $54 $215 M 8012

Pure sine wave

Pure AC Power From Your Car Battery

Compact German engineered 150W inverter - provides mains power anywhere, anytime! Delivers pure AC power to difficult loads, such as laptops, switchmode devices & game consoles. Includes USB output for charging a phone/MP3 player. 12V input, 150W continuous, 300W surge rated. Size. 200 x 115 x 36mm.

High Power Compact Pure Sine Wave Inverter Ideal For 4WD's & Caravans!

Pure sine wave 12V inverter with high 1000W surge rating suitable for powering difficult loads, including switchmode power supplies. Chassis may be mounted under the car seat. Dual power outlets. 300W rated. Size: 225 x 242 x 80mm.

2 Volt 200Ah SLA Batteries

Used in banks for remote power systems. Link terminals provided with each battery. Premium Henda brand provides long life & high performance.

SA5059 300mm battery bank link lead $14.95ea.

SAVE $50 $179ea S 5059

Home & Business Solar Guide

A must have book for anyone wanting to create their own remote power solar system for home or business. Collyn Rivers is Australia's leading solar expert and provides expert tips on 'getting it right every time'.

VALUE! $47.50 B 2330

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ONE-STOP ELECTRONICS SHOP

TOP VALUE TEST GEAR

Get more test equipment for your dollar...

Q 0203

NEW!

$1149

Ultra compact. 75% smaller than the old CRT versions!

Specifications	
Bandwidth	100MHz
Sample Rate	1GSa/s or 500MSa/s
Auto measure	32 parameters
Math functions	+, -, multiply, FFT
Ports	USB & RS-232C
Display	7" TFT 480x234px
Dimensions	399Wx149Hx110D
Weight	2.4kg

Atten® 100MHz R&D Digital Storage Oscilloscope

Perfect for those in R&D, product development or service of complex electronic equipment. Features 2 channels with real-time sampling modes of 500MS/s or 1GSa/s. The 64K colour 7" TFT display screen can be set up to simultaneously display the waveform plus indicate the measured wave voltage, peak to peak plus RMS, frequency, duty cycle etc. Using the USB lead and software supplied realtime adjustments can be made of the scope. Any stored data or settings can be either saved to a USB stick or downloaded to a PC. If connected to a PictBridge® printer, screenshots can be printed without a PC.

SAVE 22%

$155

Q 1536

Professional 2.7GHz Frequency Counter

High accuracy counter covering a range of 10Hz to 2.7GHz in two ranges; 10Hz to 100MHz and 100MHz to 2.7GHz. Ideal for servicing and calibrating RF equipment, radio mics, CB's & transceivers. High input sensitivity. Period, frequency, pulse count (totalise) functions. x20 input

Test Wiring Polarity & Continuity In A FLASH!

Allows a single user to quickly identify two wires, even when the wire ends are located in different rooms. Makes testing a breeze, even on long cable runs and wiring harnesses. Includes 9V battery.

Top value for installers!

SAVE 40%

$24 Q 2024A

Precision Impedance Meter

Measures transformer & speaker impedance accurately and easily. Applies a test tone to any speaker or transformer circuit. Suitable for both 4-8 ohm & 100V line systems. Requires 6 x AA batteries.

SAVE $50

$199

Q 2005

Q 3002

SAVE 24%

$15

Detect Lethal AC Voltages Without Contact

Non-contact AC detector with LED light. Essential for working with AC wiring. Lights up when near any AC source (100-600V @ 50-60Hz). Fits right in your pocket.

SAVE $26

$99 Q 1284

Professional 'Contact Free' Digital Thermometer

With twin laser guided beam for pin point accuracy! Lightweight, "point and shoot" temperature measurement. Provides accurate temperature readings from a distance. Ideal for measurement in dangerous places, or when equipment is operating. Incredible accuracy from -35°C to 800°C. 12:1 optical resolution. 300ms response. 1% accuracy.

SAVE 25%

$44

Q 1270

Great for lighting & CCTV installation

Measure Light Levels Instantly!

Checking light levels is an essential part of selecting the right CCTV camera. High precision sensor provides instant, accurate lux readings. Includes protective case.

Get an accurate measurement in seconds!

This laser tape measure provides an instant "one touch" measurement - up to 30m. Excellent accuracy down to just ±3mm. Plus calculation modes such as add, subtract, pythagorean, square & cubic measurements.

NEW!

$199

T 2251

Multimeters Galore - SAVE 20%

NEW!

$289 Q 1198

2 Year Warranty!

Precision True RMS USB Datalogger Multimeter

Ideal for use in R&D engineering or service centres. Accurate to 0.05% with a 50,000 count resolution for testing digital devices. Displays measured value, bar graph, time/date, min & max readings. 18,000 points can be recorded and stored in memory reviewable on screen or via PC. Includes carry case, software, test probes & thermocouple.

Q 1067

SAVE 20%

$55

Jumbo Display 28 Range DMM

Includes temperature probe at no extra cost! Excellent for the service technicians or enthusiast.

- Massive 20A rating
- AC/DC to 1000V
- Auto power off
- Temperature
- Frequency
- Data hold

Q 1079

SAVE 20%

$70

USB Autoranging Datalogger

A complete datalogger with software suite allowing analysis of circuit operation over time.

Features:

- Autoranging with override
- Data hold
- Duty cycle
- AC/DC current to 10A
- Includes temp probe.

Top Value!

Q 0964

SAVE 28%

$50

AC Clamp & Digital Multimeter Combo

Slimline design combines both digital multimeter and an 400A AC clampmeter into one unit. Superb ease of use makes it perfect for working on live equipment. An essential for high voltage technicians, electrical trades etc.

Features:

- Capacitance
- Temperature
- Resistance
- 400A AC
- DC V to 600V

AC & DC Testing!

Q 0966

SAVE $30

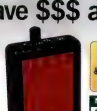
$99

600A True RMS AC/DC Clamp Meter

Accurately measures AC or DC current to a MASSIVE 600A! A professional unit with advanced features such as true RMS AC measurement, resistance, temperature, capacitance, zero & hold functions - All supplied with carry case & test leads. Max input 600V.

DIY PROJECTS

Save $$$ and build it yourself!



Compact low noise & distortion design

NEW KIT!

$59.95

K 5508

Low Distortion Headphone Amp Kit

(SC May '11) Why put up with garbage sound from your portable music player? This compact device not only boosts the volume output of your device, but significantly improves fidelity - lowering distortion & noise. Provides up to 200hrs use from 2xAA batteries (not included)

NEW!

NEW KIT!

$45.95

K 6125

Versatimer Switch Kit

(SC June '11) Drives a 12V latching relay for switching applications requiring a low current drain. Also provides a battery discharge feature for use with SLA batteries. In-built timer (1s-59hrs) can be triggered from external contacts.

NEW!

NEW KIT!

$49.95

K 9552

Mini-Maximite BASIC Embedded Module Kit

(SC November '11) The 'little brother' of the Maximite kit. Utilising identical software it is designed as an intelligent controller for embedding into larger systems. Features 20 I/O pins, 128K RAM, VGA/composite out, USB2.0 & keyboard interfaces. All from one low cost IC!

K 5136

SAVE 20%

$39

2x20W 12V Amplifier Kit

(SC May '10) This compact stereo amp module puts out 2x20W RMS into 4Ω and is 12V powered (SLA battery or plugpack). Bass & treble controls. Distortion typically <0.03%.

SAVE 12%

$42

K 6120

Smart Fan Controller Kit

(SC July '10). This compact module regulates the speed of up to eight 12V fans. Measures up to 4 temperature points & smoothly controls fan speed. May be monitored using PC software. Ideal for computers, greenhouses, home breweries, amp cooling etc.

SAVE 10%

$175

K 1143

GPS Boat Computer Kit

(SC October '10) Tells you exactly where you are - never get lost at sea again. Also shows speed and heading - plus it will navigate you back home - or to that secret fishing spot! It even displays fuel consumption, along with a host of other vital information.

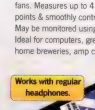
K6026

SAVE 15%

$75

Solar Powered Alarm Kit

(SC March '10). A handy security solution for sheds, boats, caravans and remote buildings. Coupled with an N 0700 solar panel this alarm system may be used with up to 3 sensors (eg: reed switch/pressure mat). Includes PIR movement sensor & siren.
N 0700 5W solar panel $29.95
S 5075B 1.3Ah SLA battery: $19.95



Works with regular headphones.

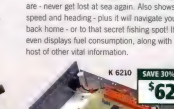
K 5547

SAVE 15%

$33

Improve Your Hearing Without Expensive Aids!

(SC Sept '10) Hearing Loop Receiver Kit. Picks up signals from a hearing loop (or T-coil), found in PA systems at places of worship and function centres. It even works with home made hearing loops. Requires 9V battery.



K 6210

SAVE 30%

$62

Great for remote monitoring and control systems

Web Server In A Box (WIB) Kit

(SC Nov '09) Host and update your own website without the need for a computer! This compact box houses a chip based server that may be accessed anywhere in the world - even from a mobile phone. Beyond serving web pages, it also monitors & logs 4 analog inputs, or control 4 digital outputs.

A dream for model rail enthusiasts!

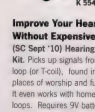
K 6015

SAVE $56

$119

Rail Power Controller Kit

(SC Sep-Oct '08) A great value model railway controller offering remote control, pulse power for realistic low speed train movement, speed bargraph & adjustable braking inertia. 16-17V output up to 6A. A 1012 remote to suit $19.95. 240V operation.



Measures to 65,000 RPM

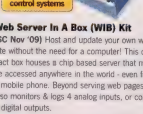
K 2510

SAVE $10

$79

LED Strobe & Tachometer Kit

(SC August '08) Allows you to measure the RPM of fans, shafts, propellers or anything that rotates! Readout displays RPM and frequency. 1RPM resolution. Adjustable flash period & divider options. Requires 12VDC power.



SAVE 25%

$60

K 2920

Cut Office Power Consumption

USB Mains Sensing Switch Kit.
(SC January '09) Monitors your PC's USB port and automatically turns all your gear on and off as required. No need to crawl under the desk to disconnect devices!

Sale Ends April 30th 2012

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2012/04

Maximite Q&A, etc

Thousands of Maximites have now been built and have worked perfectly the first time. The design of the Maximite has proved to be remarkably robust, so if you have a problem with one you have just built, it most probably will be something specific to your Maximite and not a fatal design fault or software issue. However, there are some common problems that constructors do experience so we asked the designer, Geoff Graham to come up with the six most common....

1: The power LED does not light and the Maximite draws very little current (normal consumption is 125mA). Capacitor C5 (in the Maximite) or C3 (in the mini Maximite) is nearly always responsible. It must be a low ESR Tantalum or ceramic capacitor (NOT aluminium electrolytic) since the PIC32 is very sensitive to its characteristics. If you suspect C5, try replacing or paralleling it with a higher value and/or a higher working voltage (both of these will improve the ESR). The best solution is to solder a surface-mount 10µF ceramic capacitor with Y5V dielectric (available from au.element14.com) between the solder pads for C5 (or C3). The kits from Altronics or Jaycar should not have this problem but it is worth a try.

2: Using USB power as the power source is the cause of many problems with varied symptoms. Many computers or hubs cannot supply clean power so before you try anything else, plug an external 9V to 12V power pack into your Maximite and test it.

3: Errors reading or writing to the SD card. This has proved to be an on-going issue with about 5% of cards and I have not got to the bottom of why some work in the Maximite and others do not. Some cards have buggy controller logic when used in SPI mode and this may be the reason. The only solution is to try a few different cards. A list of cards that are known to work is available at duinomite.com/Maximite-control

4: The Maximite resets when you plug in an SD card (this is rare). This is due to the sudden load of the SD card causing a glitch on the 3.3V supply rail. The solution is to use a different SD card or solder a 22µF low ESR Tantalum capacitor across the supply rails very close to the SD card connector pins.

5: You get an error when writing to the internal flash drive A. This is caused by the 3.3V supply rail to the PIC32 being too low. When writing to the flash memory the supply to the chip must be at least 2.9V.

6: You think that you have accidentally damaged the chip or that it seems to be running too hot. Don't slash your wrists at this point (you can leave that till much later). The chip is very tough and your problem is most likely to be somewhere else. Also, the PIC32 does run hot in normal operation (it has a lot of work to do).
If you are really convinced that your chip is dead you can purchase a programmed PIC32 replacement from SILICON CHIP for $15 plus $10 for postage & packing.

If you want to ask more questions there is a good community forum at:
http://www.thebackshed.com/forum/forum_topics.asp?FID=16

And some recent questions and answers on the Maximite:

Q1: Is it possible to program the Maximite computer in C instead of Basic? I really want to get into this unit but am not looking forward to dealing with Basic script.

A: *The whole firmware is written in C including MMBasic. It would be very easy to replace the MMBasic part your own program written in C. You would still have access to the video and keyboard routines - so it will give you just what you want. The source code is available from the SILICON CHIP website or at http://geoffg.net/Maximite.html*

Q2: I want to use the Maximite with my laptop instead of the monitor and keyboard. The Maximite web site suggested using TerraTerm as the emulator. I downloaded it but it does not support USB and seems like a very old program. Is there a way to do this.

A: *TerraTerm works fine. Follow the instructions included with the SILICON CHIP Serial Port Driver. It uses PuTTY as an example but TerraTerm works just as well.*

Q3: I am interested in utilising the Maximite project to make a curve tracer for vacuum tubes (Yes, big hot valves). I would be interested in how one could interface high voltages up to 1000V DC to the analog inputs, as well as display the results on a computer screen. I have the actual curve tracer circuit ideas sketched out but not the Maximite interfacing.

A: *The third article on the Maximite (May 2011) describes how to scale the input voltage using a couple of resistors to measure higher voltage. You would need to be careful in selecting the resistors for the high voltage but the principle of scaling the input voltage is the same and will apply to your project.*

Q4: I have a Macintosh. How can I update MMBASIC on my Maximite as your software is Windows only?

A: *This program (http://code.google.com/p/mphidflash/) will work with Macintosh and Linux computers. Instructions for using it are included with the latest updates for MMBASIC.*

Q5: I have been told that your articles on the Maximite explain how to connect to the Maximite via the USB port on a PC. Apparently the Maximite is seen as a virtual serial port by the bigger computer and to do this you need a Terminal program such as Putty. This program is very complicated and mainly refers to connections to the internet via a server. I have not been able to use it to get a connection to the Maximite via my HP Pavilion DY 6000 laptop using Windows XP. Can you tell me the steps to use with a Terminal program to get the link.

A: *The procedure for connecting to the Maximite using the serial port is explained at the bottom of the PDF file "Installing the USB Serial Port Device Driver" which is included in the Silicon_Chip_USB_Serial_Port_Driver.zip.*

To summarise:
First, determine which COM port the Maximite has been assigned to. Go to the start menu, control panel, system, hardware, device manager. Scroll down and click the "+" next to "Ports (COM & LPT)". You should get a list of ports. Determine which is the one for the Maximite. It is probably the highest numbered COM port.
Then run PuTTY. Click on the "Serial" option (just below "Port" in the upper-right corner). Change the COM port number to match the one you noted earlier, then click on the "Open" button at the bottom. You should then receive a message that you are connected to the Maximite and you can then type commands.
If you want to send and receive files from the Maximite using xmodem then you may need to use TerraTerm instead. The procedure will be similar. SC

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On Geoff Graham's website (http://geoffg.net) there is a library of programs for the Maximite that you can download. Two of them (GRAPH.BAS and BATTERY2.BAS) contain routines to draw graphs and if you examine these you will see how easy it is.

Vintage Radio

By Rodney Champness, VK3UG

Philips 196A 4-Valve AC/ Battery Portable Receiver

Designated the 196A, this interesting little portable radio from Philips uses valves and can be run from either batteries or mains power. It was designed as a low-cost set but is still quite a good performer.

THE PHILIPS 196A was produced during the late 1950s and early 1960s, a time when many manufacturers were already designing and building transistor portables. However, many customers were reluctant to buy the transistor radios of the era, as their performance at that early stage was far from inspiring.

To overcome this reluctance, some manufacturers built both valve and transistor receivers in nearly identical cases. This allowed customers to choose the type of set that best suited their needs and also gave them time to adjust to the changeover to fully-transistorised sets.

The 196A was one such set. It's a relatively small, portable valve receiver and was manufactured right at the end of the valve era.

As can be seen from the photos, the case is a little unusual. According to the supplied information (on the inside of the set), it's made from sandstone-coloured, rippled leatherette over stiff cardboard sheets, a style that was used for many portables of the time. It measures 280mm long x 180mm high x 115mm deep and weighs around 3kg without batteries.

Note that the case isn't a perfect rectangle, so these are the greatest dimensions in any direction. And although similar in style, the later Philips 199 transistor model used a case that was slightly smaller and had pushbutton controls along the top.

The 196A valve portable has just three controls: a partly-recessed volume control at top left, a hand-span dial on the front panel and a small lever located under the lefthand end of the carrying strap. This lever controls a 3-position switch which switches the set on or off and selects between battery and AC operation.

This power switch isn't easy to see and appears to be something of an "add-on". Philips certainly could have done a much better job when it came to positioning this control.

Circuit details

The 196A's circuit is quite conventional. The front-end employs a loop-stick ferrite rod antenna and this forms a tuned circuit with one gang of the tuning capacitor. The signal is then coupled to the grid of a 1R5 pentagrid converter valve.

The local oscillator, which is also part of the 1R5, operates 455kHz higher than the signal frequency. The two signals are then mixed together and the resulting 455kHz signal fed via a double-tuned intermediate frequency (IF) transformer to a 1T4 IF amplifier pentode (the other signals from the mixer are rejected). From there, the amplified signal is fed via another double-tuned IF transformer to the detector/AGC diode in a 1S5 valve.

The recovered audio at the detector is then fed via the volume control to the pentode section of the 1S5 and following that to a 3V4 audio output stage. A speaker transformer in the plate circuit of the 3V4 couples the audio from the high-impedance plate

circuit to the low-impedance (3.5Ω) 100mm (4-inch) loudspeaker.

In addition, the receiver employs a simple AGC system. The AGC voltage is derived from the only diode in the 1S5 and this is applied to the 1R5 in the front end. No AGC is applied to the 1T4 IF amplifier.

Because this receiver works on both battery and AC power, the valve filaments are wired in series. The current drain through them is up to 50mA at 6.5-7.5V on either batteries or AC mains.

The mains transformer has two windings: a tapped mains input and a secondary producing around 130V. A selenium half-wave rectifier is used to produce an HT voltage of nominally 90V at 10-13mA to the valve plates and 7.5V for the filaments via dropping resistors. This may not be very efficient but it ensures good filtering of the filament voltage (efficiently filtered low-voltage power supplies didn't become available until transistors became common).

The batteries are relatively small (to fit inside the case), so a life of around 100 hours would be expected. It uses a 490P 90V battery for the HT and a 717 battery that supplies 7.5V.

Cleaning & repairing the case

A comprehensive set of instructions on removing the chassis from the cabinet is pasted inside the rear cover (see photo). In fact, it's one of the most comprehensive I have seen, so full marks to Philips for this.

The set featured here had obviously had a hard life up until the time it was pensioned off. Some of the trim on the case had come loose and there were (and still are) several paint marks on it as well. It was also quite grimy on the outside.

Having removed the chassis, I removed the plastic grille from inside the escutcheon, by levering it away from the case with a broad-bladed screwdriver (it had been attached with contact adhesive). That done, I set about giving it a thorough clean.

I usually place plastic and Bakelite cabinets in a laundry tub with warm soapy water and scrub them clean with a nail brush. However, that's not possible with a thick cardboard-lined case, as water will damage the cardboard.

Instead, I simply dampen the outside of the case with soapy water and then scrub it clean. With continued scrubbing, the cabinets usually come up looking quite good, just as it did in this case. The plastic grille and the volume control knob were then cleaned by immersing them in soapy water and scrubbing them with a nail brush. These parts, along with the case, were then placed in the sun to dry.

This is the view inside the set without the bottom chassis cover in place. The label attached to the rear cover details the chassis removal procedure. It also shows the valve locations, the alignment points and the battery details.

Once the cabinet had dried, I tried lightly scrubbing the paint splashes with some acetone and while that helped remove some of the paint, I also managed to go through the original paintwork in one or two places. It's no big deal and I will try touching up these areas with paint when I have time.

Having cleaned the cabinet, I realigned the trims around the plastic grill, filled the gaps with contact adhesive and clamped the trims in place. This took quite some time, as I had to allow the adhesive to set in each spot where it was applied, before moving onto the next piece.

Finally, the two covers that go over the ends of the handle were quite dull and grimy. I rubbed automotive cut and polish on them and used a small screwdriver to push the polishing cloth into the grooves in the covers to achieve an excellent result.

Overhauling the electronics

The inside of the set was quite clean apart from some loose dust on various components. Unlike many other sets of this era, there was no sign of any rust or other corrosion.

As a result, a quick dust-out with a 12mm paint brush was all that was required to clean the circuit components and the chassis.

Having got rid of the dust, it was

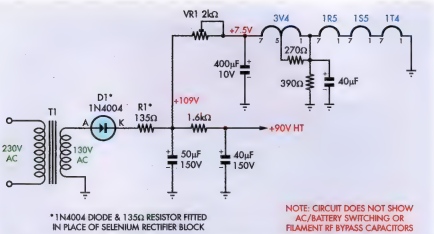


Fig.1: a simplified circuit of the power supply, showing how the 90V HT rail and the filament supply rail are derived. The original selenium block rectifier has been replaced by a 1N4004 silicon diode and a 135Ω resistor.

now time to overhaul the electronics. I began by using a high-voltage insulation tester to check for leakage between the primary of the mains transformer and both the chassis and the secondary winding. There was no discernible leakage, even with the tester set to 1000V.

That done, I checked the continuity of all the battery valve filaments using a DMM and found that they were all intact. These filaments are quite delicate so care is needed to ensure that the correct filament voltages are applied.

As stated above, this set uses a half-wave selenium rectifier block and this is bolted to the chassis. They are not very efficient and do get quite hot. In addition, their impedance tends to go high, which lowers the loaded output voltage considerably.

As a result, I applied mains power to the set and checked to see whether the output voltages from the power supply were indeed around 7.5V and 90V. This showed that the filament voltage was around 3.5V, while the high tension (HT) was just 65V. These readings were both much too low and from experience, it pointed to the selenium rectifier being faulty.

I decided to leave the existing rectifier block in place and connect a 1N4004 diode in series with a 3.3kΩ resistor across it. This gave slightly higher voltages out of the power supply but they were still too low so I progressively reduced the 3.3kΩ resistor in series with the diode until I got the correct voltages.

Unfortunately, while I was wiring these parts in place, one of the lugs broke away from the selenium rectifier block. As a result, it was removed and a small tagstrip fitted in its place, with the diode and resistor wired to it. The series resistor value came down to 135Ω before I got the correct voltages for the filaments and plate supplies (ie, 7.5V and 90V). In practice, this 135Ω resistor was made up of using a 180Ω 5W wirewound resistor and a parallel 470Ω 1W carbon resistor.

Fitting a 135Ω resistor in series with the diode means that the circuit more closely mimics the characteristics of a selenium rectifier.

Keep in mind that a 1N4004 diode has a peak inverse voltage (PIV) rating of 400V volts. With a 130V secondary transformer voltage, the peak voltage applied to the 1N4004 is around 130 x 2.8 = 364V. I usually take the transformer voltage and multiply it by three to give me the PIV plus a small margin for spikes on the power supply line but if in doubt, always use a diode with a higher PIV rating.

Because the voltages are not that high in battery sets, I decided to run the set for a short time to see whether I could get it to operate before replacing any leaky paper capacitors. There was no output but touching the volume control produced a "blurt" from the speaker. I then wriggled the valves in their sockets and this produced some loud crackles.

As a result, I switched the set off, removed the valves and sprayed each socket with Inox (a spray lubricant, cleaner). I then reinserted the valves, slightly rocking them from side-to-side as I did so to clean any corrosion off the pins. With power reapplied, the set then worked but the audio output sounded quite unpleasant.

At that stage, I quickly switched the set off again. It was important to keep this test short, to ensure that no damage to the valves occurred.

Having proved that it worked (in a fashion), it was now time to replace any leaky paper capacitors that might affect the set's operation. In the end, I replaced all these capacitors except for a 100nF low-tension RF bypass and a 4.7nF top-cut filter on the plate of the 3V4. The capacitors that were removed had between 1.5MΩ and 7MΩ of leakage resistance, so it was no wonder that the audio was distorted.

This receiver is generally quite good to work on but sometimes you have to dig down through up to three layers of components to get at the parts. As a result, it can take quite some time to replace or test some components – not that you have to do that often.

The selenium rectifier is shown here at left, together with the diode that replaced it.

Mains power lead

The mains power lead is a 2-wire (figure-8) type with a moulded 2-pin mains plug and a 2-pin socket that plugs into the side of the receiver. It isn't practical to replace the lead with a 3-core lead and the set is largely double insulated anyway. In fact, if the power switch had a plastic recessed type knob, it would probably comply with the latest electrical safety standards.

In the meantime, the set can be used with a 1:1 (230V-to-230V) isolation transformer.

Unlike this set, some sets of the era were designed to run from both AC and DC mains supplies (ie, 200-250V AC/DC) and so didn't use a power

transformer. These particular sets were "hot chassis" (ie, the chassis and various components operated at mains voltages) so extreme care was needed in servicing them, otherwise electrocution was a distinct possibility.

Power supply

Fig.1 shows a simplified circuit of the power supply used in the Philips 196A. The output from the rectifier and its series 135Ω resistor is filtered using a 50μF electrolytic capacitor and is then fed via a 1.6kΩ resistor to provide the 90V HT supply rail. This rail is further filtered using 40μF electrolytic capacitor.

By contrast, the filaments are fed from the 109V rail via an adjustable 2kΩ wirewound resistor (set at 1.95kΩ ohms in this set) which reduces the voltage to 7.5V at 50mA. A 400μF electrolytic capacitor filters the filament voltage which is then applied to the 3V4. It's then filtered using another 40μF electrolytic capacitor before being fed to the filaments of the remaining valves which are in more critical sections of the receiver.

Typically, the valve filaments were wired in series so that the total filament current remained at 50mA. This applied whether four or five valves were used, with a 7.5V filament supply used for a 4-valve set and a 9V supply for a 5-valve receiver.

In addition, the filament circuit has a 270Ω resistor across one half of the 3V4's filament (pin 1 to pin 5), with a 390Ω resistor then connected to chassis. For those unfamiliar with series-connected filament circuits, this may appear to be a rather strange arrangement.

The first thing to realise here is that the plate and screen currents of a filament valve go through the filament to earth, thereby increasing the filament current by the sum of these two currents. As a result, the 270Ω resistor is included across half the filament of the 3V4 so that the currents flowing through both sections are the same.

The 3V4, which is the audio output valve, draws around 7-9mA and so this extra current is "bled" to earth (chassis) via the 390Ω resistor, thus keeping the current through the filaments of the 1R5, 1T4 and 1S5 valves close to 50mA. Without this bleed resistor, the current through these filaments could go as high as 60mA.

As a result, the voltage across each filament is kept close to the required 1.5V.

Because these remaining valves have a current drain of just 1-2mA, it's not usually considered necessary to balance the current through their filaments (and thus the voltage across them), although some designs do include this.

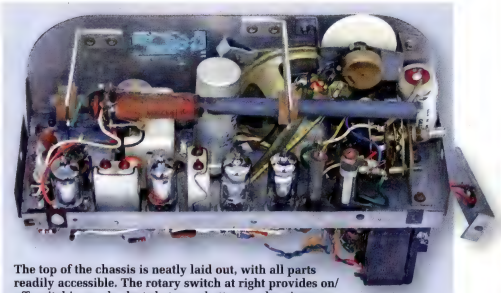
During the course of my checks, I found that the 1R5's filament voltage was around 1.65V, which is much too high for the valve to have a long life. The reason was simple enough – the 390Ω resistor had been incorrectly wired to pin 1 of the 1R5 instead of pin 7. Once this had been corrected, the filament voltage came down to the correct 1.5V. Manufacturers in those days did make wiring mistakes. Sometimes they are obvious, sometimes not.

There is also one potentially serious problem with this type of power supply. If a valve filament goes open circuit, the voltage at the filament feed point (7.5V in this set) will quickly rise to well over 100V. As a result, the 400μF 10V electrolytic capacitor across this rail will soon succumb and could even explode.

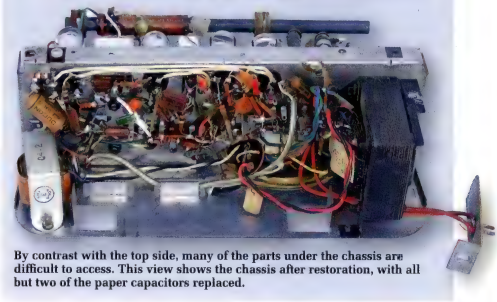
Alignment

Having corrected the filament supply wiring error, the next step was to check the alignment.

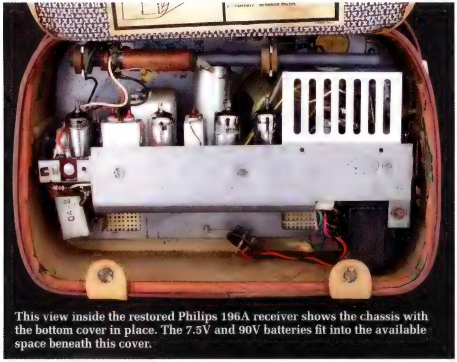
I began by tweaking the 455kHz IF transformers for maximum audio output and found that they were quite close to their correct settings. I then checked the oscillator setting by tuning from one end of the band to the other and found that it was close



The top of the chassis is neatly laid out, with all parts readily accessible. The rotary switch at right provides on/off switching and selects between battery and mains power.



By contrast with the top side, many of the parts under the chassis are difficult to access. This view shows the chassis after restoration, with all but two of the paper capacitors replaced.



This view inside the restored Philips 196A receiver shows the chassis with the bottom cover in place. The 7.5V and 90V batteries fit into the available space beneath this cover.

enough to not warrant adjustment.

The next step was to slide the tuned coil along the ferrite rod antenna to tweak the performance at the low-frequency end of the dial. Once again, very little adjustment was needed. I then tuned the set to around 1500kHz and adjusted the antenna tuned circuit trimmer capacitor. It too was close to its optimum setting.

Finally, I resealed the adjustments by re-melting the original sealing wax using a soldering iron.

The set now turned in an excellent performance, especially considering that it only has four valves. And with an external antenna and earth connected, the stations romped home.

An intermittent problem

Unfortunately, the set still had a problem. Although it generally worked quite well, it would also occasionally go completely dead. And to make matter worse, the fault was intermittent.

I checked the voltages at various point around the circuit when it was dead and also when it was working and they were all correct in both situations. I could also get a healthy blurt from the speaker if I touched the top of the volume control, which indicated that the audio section was working.

I then checked the front-end of the receiver and although it appeared that the 1R5 was oscillating, it wasn't producing any 455kHz output according to my tuned signal tracer.

Suspecting a faulty valve, I replaced both the 1R5 and the 1T4 but that didn't cure the problem and subsequent tests proved that they were OK. I then found that when I wriggled these valves around in their sockets, the set would come good. As a result, I re-cleaned the contacts as it appeared that there may have still been some corrosion on either the valve pins or the socket pins.

Once that was done, the set worked quite well for some time but then suddenly went dead again. This time, there was no blurt from the speaker when I touched the volume control, so the fault lay in the audio circuitry.

Using a signal tracer, I quickly determined that the receiver was working right up to the output of the speaker transformer. I then checked the speaker and it also tested OK, with around 3Ω of resistance across the voice coil. This was rather puzzling as the fault had to be here somewhere, so I re-tested the voice coil a few times and found that it had intermittent continuity.

Eventually, I traced the fault to the spot where the flexible wire joins to the voice coil winding on the speaker cone. Unfortunately I couldn't repair it, so a new speaker had to be fitted.

Removing the speaker is straightforward. The first step is to disconnect the wiring to it, after which the front panel is separated from the chassis by removing four screws. It's then just a matter of undoing the four screws that hold the 100mm speaker in position and sliding it out.

I didn't have a Rola speaker in my spare parts bin but another, slightly smaller speaker which I had rescued from old equipment did fit. And that cured the intermittent fault once and for all.

Summary

Although the Philips 196A is a rather utilitarian receiver, it's still quite pleasant to use. It doesn't have the appeal of a beautifully-restored timber cabinet receiver but it's a somewhat unusual set that's worth having in any collection.

It works quite well, especially considering that it's a battery/mains portable set with just four valves. It's also quite compact and the instructions inside the case are extremely helpful when it comes to servicing.

Finally, despite its age, there were relatively few problems – just a dud selenium rectifier, some dirty valve sockets, a small wiring error and an intermittent speaker voice coil. Fortunately, the 1R5 valve in the front end had survived having a higher-than normal voltage across its filament. SC

Many of the parts under the chassis are "buried" two or three layers down, which can make replacement difficult and time-consuming.

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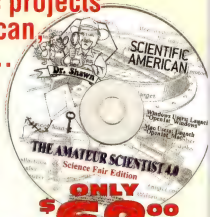

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Mains tones interfere with lighting desk

I am hoping that you can help me fix a problem I have with the 4-Channel Lighting Desk (SILICON CHIP, June & July 1991).

I am part of a local amateur theatre group and recently found this unit broken and unloved at the bottom of the group's electrical box. The group was at the time using an array of switched plug boards to control their lights which, as you can imagine, leaves much to be desired. Luckily the controller was mostly intact so armed with a photocopy of the original article from your archives I managed to restore it to its former glory.

It mostly just needed new switches (which had fallen apart), faders cleaned and lubricated (which had seized), new custom made timber fader knobs (which were missing) and a complete change of wiring (which I didn't trust). All the electronics were fine, including the Triacs, which surprised me since there was some sooty evidence of previous shorts. The controller has since been doing a great job running our lights and the group is very happy with the step-up of professionalism, even though it now puts extra pressure on the actors to match our new lighting standards.

Our most recent season though has been running longer into the night than earlier shows and a new problem has now emerged. Starting at around 22:00, the brightness setting suffers periods of instability in bursts lasting maybe 15 seconds. During each burst, the lights rhythmically vary in brightness by about 10-20% at a frequency of about 1Hz.

My suspicion is that the controller is sensitive to the mains ripple control signals that start at around that time each night in our area. This unwanted disco effect can be somewhat mitigated by increasing the overall brightness but is nevertheless off-putting for our otherwise riveted audience.

My first guess (with no evidence) would be that the ripple control signal is causing some sort of harmonic effect with the zero-crossing detector (IC2a), resulting in its pulse output varying slightly from the true zero-crossing point of the mains waveform. This then leads to a shift in the timing of the following ramp waveform and ultimately an error in Triac switch-on times. If so, then maybe it's possible to put some sort of filtering on the signal that's fed to pin 6 of IC2a that will remove the ripple signal component? (D. P, via email).

● Control tones would be responsible for the lamp brightness modulation. The filtering is at pin 6 of IC2a (the LM339) using a 1kΩ resistor and 10kΩ resistor divider from the transformer diodes and a 1nF capacitor.

You can increase the 1nF capacitor to improve filtering from control tones. A value between 10nF and 47nF could be used. A too large value will shift the detected zero crossing point and affect the lamp dimming control.

Noise problem in AM radio

I built the AM Radio (SILICON CHIP, January 2012) and I am getting noise in the audio output which I can also see at the input to the LM386 (using an oscilloscope). It appears to be RF, as if the RF filtering is not sufficient. In the circuit details the 10Ω resistor from the output of the TA7642 is described as an RF stopper resistor but shouldn't it need some capacitance, say across the 10kΩ volume control, to be effective?

The 470pF capacitor at the input of the LM386 would need about 33kΩ from the output of the TA7642 to roll off (-3dB) at 10kHz. (R. S., via email).

● The output of the TA7642 is already rolled off using the 18nF capacitor at the demodulated output and so there should not be too much RF signal at the 10Ω resistor. It works as an RF stopper to isolate the LM386 from the RF stages.

Noise can occur in the audio when the bias (using VR2) is not set for

Ultrasonic Cleaner Should Produce Cavitation Bubbles

I built the Ultrasonic Cleaner, hoping it would help with cleaning auto parts but apart from the chuffling noise it makes it seems to do little more than expected from normal soaking in parts cleaner. YouTube shows videos of ultrasonic cleaners (**http://www.youtube.com/watch?v=xhGyK6MpkOQ**) punching holes in tin foil but this kit will not do that.

Should I expect at least some bubbling action? The unit draws just 1.1A in normal mode and about 2.2A in constant mode from a 12V supply. (K. R., Auckland, NZ).

● The Ultrasonic Cleaner will punch holes in aluminium foil and produce cavitation bubbles in the water, when working correctly.

The points to check are whether the fuseholder clips are installed correctly. These clips have end stops for the fuse and if the clips are orientated with the end stop inward then the fuse will not make good contact with the clip and the clip will be held open with the end stop section. That can reduce ultrasonic drive to the transducer, due to lack of supply current.

Ensure that the ultrasonic transducer terminals are not wet when the transducer is placed in the water; it needs to be encapsulated or otherwise isolated from the water. Have a look at the photo of the one shown in the Mailbag pages of the March 2012 issue.

Finally, note that the power supply must be capable of delivering up to 2.5A peak.

Warning Device For Mobility Scooter

I require some help in locating a musical horn or warning device for my wife and a female friend of hers for use with a mobility scooter. The scooter has a horn fitted as standard but it is obtrusive, to say the least. People do not like to be tooted at in malls and other public places and in very crowded places it is quite difficult to move through a crowd without the horn in continuous use, which upsets some people.

So I have been looking for something that will get attention but not in an aggressive way; some type of high-pitched tinkle sound or musical sound would be ideal. I also need a warning flashing light or strobe that can be mounted on to a flexible pole about a metre or so high, that can be seen in bright daylight. This is for use when she is crossing intersections, as car drivers do not see a scooter because of its low height and sometimes it is necessary to move onto the roadway for a short distance to get around cars or obstructions on the footpath.

I have tried some flashing LEDs. These are OK in the dark but useless in bright daylight. The only thing that meets the requirement is a flashing beacon off a tractor but these are huge and much too heavy. (P. W., Goulburn, NSW).

- We can understand people not liking being tooted at; it means "get out of my way!".

Possibly you should consider something along the lines of our Diesel Sound Simulator. This was intended to be housed inside model railway locomotives and produced the sound of a diesel which raised and lowered in pitch according to the speed of the loco.

You could adapt this to your wife's mobility scooter. It could be connected to monitor the voltage across its motor and could be modified to produce a somewhat higher pitched sound which would attract attention without annoying people.

The design was published in the December 1992 issue and we can supply a photocopy of the article for $12 including postage. Note that we do not have a PCB for this design.

As far as a flashing beacon is concerned, why not use a LED strobe light intended for burglar alarms, such as the Jaycar LA-5328?

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minimum noise, or the supply via Q1 is not correct or the tuning coil is open circuit. You can also experiment with the 2.2kΩ resistor feeding the supply to IC1 from the emitter of Q1. Values between 470Ω and 10kΩ can be used.

Headphone amplifier comparison

In the September & October 2010 issues you published a project for a Headphone Amplifier. Could you point out where it stands against the Studio Series Stereo Headphone Amplifier published in 2005; ie, where it is better or worse and for what reasons? (J. M., via email).

- Comparing the distortion curves of the two designs reveals that the newer unit has a generally much improved performance under all conditions except for 600-ohm headphones. In this latter case, the distortion in both designs is on a par.

In addition, the later design is a complete self-contained unit whereas the November 2005 design was only a PCB module.

Headphone amplifier needs AVC

I was excited when I saw your Hifi Stereo Headphone Amplifier in the September & October 2011 issues but disappointed that it didn't have what I think is a most sought-after feature. This is an Automatic Volume Control which would control the audio when changing channels on the TV. Every person I know is frustrated at having to constantly vary the audio volume.

I did notice that your Hearing Loop Signal Conditioner (January 2011) had a compressor stage containing a "Compander Chip" (SA571), which could be set up to expand or compress an audio signal. I am not experienced in audio design but I was hoping that somehow this chip could be used to automatically vary the volume, rather than my present system of muting the sound when the advertisements are on.

Troubleshooting The Solar Lighting System

I built the Solar-Powered Lighting System project (SILICON CHIP, March 2010) from the Altronics kit and it worked fine for six months but recently the lighting function has stopped working. The solar charging side of the circuit and the indicator LED continue to work as expected.

I've tested the lighting driver (Q4 & Q5) and the light circuit itself (4 x 0.5W LEDs) by removing the PIC and applying +5V to pin 6 of the PIC socket. The lights turn on as expected and stay on until I ground pin 6. So that looks OK.

All solder joints look good and flexing the board or applying pressure to individual components does not seem to have any effect, so I think that part of the work is OK. No components show any sign of damage (and no components ever felt hot when the unit was working correctly).

With the PIC in place, all set-up voltages have been re-checked at the test points and are correct. The only "strange" behaviour that I see is that the voltage measurements are no longer dependent on closing S1 (same voltage in either case). I have checked the switch itself (and the external switch also connected) and pin 7 (RB1) is at 4.88V when the switch is open and falls to ground when either switch is closed, as expected.

However, pin 11 (RB5) appears to be at 5V whether the switch is open or closed (or is it just that my voltmeter is incapable of seeing that it is being turned on and off at a high frequency?).

All tests were done with the PIR disconnected, LK1 set to DAY, LK2 set to LDR and a 10kΩ resistor in place of the LDR for consistency. In addition,I'm trying to trigger the lights using S1.

My guess is that there is either something wrong within the PIC affecting the RB1/RB5 relationship or possibly the 2N7000 (Q6). Any guidance you can offer would be appreciated.

Also what are the practical limits to the charging circuit? The original project has a 3.3Ah battery and 5W solar panel. Could it handle a 7.6Ah battery and 10W panel? I'd like to run my 6-Digit GPS Clock from it as well but 3.3Ah would be cutting things a bit too fine. (P. H., via email).

● The pin 11 (RB5) output should be normally at 0V and should go high (to 5V) when S1 is pressed or momentarily to check battery voltage and the TP3 and TP4 inputs. It's possible that IC1 is not operating correctly since your RB5 output is always high. You could disconnect power and wait until the supply drops to almost 0V on IC1, then reapply power. This will reset IC1 which may then run correctly.

If that does not fix it, IC1 may need replacing or reprogramming.

The circuit can accept up to an 18W solar panel. The size of the battery is not critical but needs to be of sufficient capacity to remain with some available charge after use between solar panel recharging, even with a series of no sunlight days.

Is there any such unit or circuit which will suit my need? (A. F., Chinderah, NSW).

● We published a Stereo Compressor in the January 2012 issue. However, we should point out that any compressor circuit will degrade the performance of the headphone amplifier.

Fridge alarm to stop midnight snackers

I am interested in your Fridge Alarm (SILICON CHIP, June 2004). I am wanting to know if you still sell them and if so for how much?

Can the time be changed on how quickly the alarm goes off and how loud is the alarm? I am wanting it to stop some clients who sneak to the fridge at night and stash food in their room, so staff can hear if they do so, without waking the other clients in the house. (B. B., via email).

● While it was our design, we did not sell the kit or the PCB. Both are now unavailable.

However, it would relatively easy to wire the circuit up on a small section of Veroboard. You can easily change the delay time for the alarm, by adjusting trimpot VR2.

The piezo alarm would be quite loud if you're close to the fridge or in the same room. By the way, if you wanted to monitor the fridge and freezer compartments, you would need two of these alarms.

Black wire corrosion risk can be reduced

I have a number of LED modules connected on a single DC supply power circuit. Each LED module has a small switching power supply. These are all commercial products. The common wire only throughout the small network of modules fails. The common wires develop a black "insulative" type surface, making soldering impossible.

It does not appear to be excess heat that's causing the problem as the copper retains it malleable metal nature. Being LEDs, it is relatively low power. I would appreciate feedback if anyone has ideas. (P. H., Milton, Qld).

● The black substance is corrosion which can be a problem in DC circuits, particularly in wet or marine environments. There is no complete solution but it is better to use hookup wire that is tinned rather than bare copper wire.

Switched capacitor filter now obsolete

I was recently using my Sine/Square-Wave Generator (SILICON CHIP, February 2000) on a valve radio when I accidentally put a high voltage on the sinewave output output which destroyed IC9 (the TL071) and took out IC6, the MF4CN-50 switched capacitor filter. Whilst I was able to replace the TL071, I'm unable to find a supplier for the MF4CN-50 IC and request your assistance in buying same.

In the event of "no-supply" could you suggest an add-on passive circuit and also how to protect the sinewave output from a high voltage? (R. W., via email).

● Unfortunately the MF4CN-50 is obsolete and it is difficult to obtain this part. Furthermore, the MF4CH-50 is an integral part of the circuit and there is no equivalent circuit that can be used to filter the waveform with the

frequency tracking provided by this switched capacitor filter.

Not many oscillators are tolerant to a high voltage applied to their output. Protection against high voltages could be improved using two diodes connected in series. These are reverse connected across the TL071 supply rails, with the output going to the centre diode connection. The anode of the first diode goes to the negative supply and the cathode of the second diode to the positive supply.

A resistor from the TL071 output to the generator output terminal (100Ω) would conduct the current when a high voltage is connected and the diodes would clamp at the supply voltage. The resistor may be destroyed in the process but the TL071 should be saved from damage.

We would also recommend our newer sinewave generators such as the Digital Audio Oscillator from June 2009 (Altronics K2543) or the one from March 2010 (Altronics K2553).

Questions on headphone amplifier

I have put together the Stereo Headphone Amplifier and the matching power supply from the October & November 2005 issues. It was stated in the article that "a full metal case is recommended for this project. Plastic will not provide necessary electrical screening!"

Can the headphone amplifier be included in the same metal case along with the power supply or should that be in a separate case? I am not including the regulated +5V output for the switching circuit. As a result of that, can the 330Ω 5W resistor be removed? (A. P., Manapouri, NZ).

- Whether it is a good idea to put the Stereo Headphone Amplifier and the power supply in the same case

Hearing Loop Conditioner Has Compressor

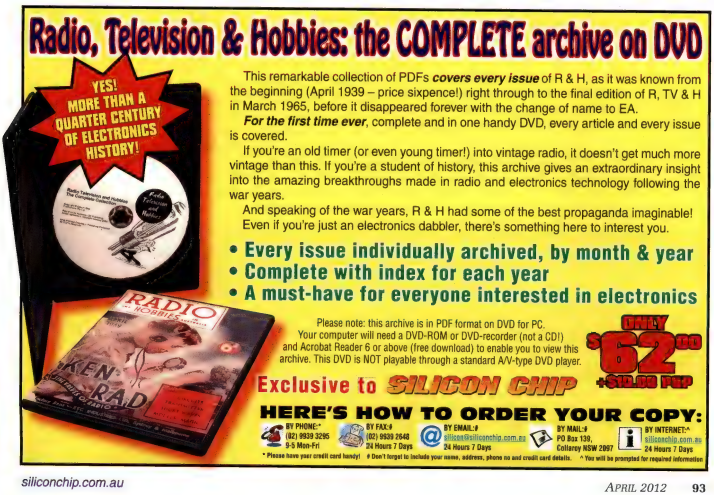
I have a problem with the volume range of TV and radio programs. My hearing loss is 75% and it is necessary to have a speaker close to my ear (about 300mm away) even when using my hearing aid.

Listening to TV is very irritating with extremely loud sound during advertisements. Many documentary programs have loud music during quiet breaks. This is most annoying as it is necessary to turn the volume down and then up again when the program resumes.

What I am interested in is a circuit that will give me a constant output regardless of the input level. Can you help out? A kit would be nice but I am quite happy to make up any circuit that can do what I want. (L. W., Pauanui, NZ).

- The most relevant project for your purpose is the Hearing Loop Signal Conditioner (published as part of the Hearing Loop series of articles) in the January 2011 issue. This does include a compressor. You would need to use it in conjunction with a hearing loop and the T-coil on your hearing aid.

If you don't have a T-coil, you would need to use the Signal Conditioner to drive a small amplifier and loudspeaker.



Changing Weather Station Batteries Need Not Be Hazardous

I loved the MiniReg Adjustable Regulator in the December 2011 issue. But well into building it, I realised that in my specific situation, it is not the answer.

The background to my comment is as follows. I purchased a weather station that I was going to install on my house roof. When I went to add the batteries on my kitchen table, I discovered just how messy it was, with very tiny screws, a waterproof seal, etc so I decided to use the MiniReg to power it so that I would not have to get up on the roof when future battery changes demanded it. It was dictated by health and safety concerns.

Before I got to finish building the MiniReg, I was reminded by my microwave that I have had another power outage which occurs all too frequently and that the set-up of the weather station would have been compromised. This is because the outage would require me to get onto the roof to re-initialise the anemometer settings so that it knows which way is north (the anemometer is set by supplying power only after you have manually pointed it north which is on every battery change or loss of power). This means that I will have to get up onto the roof after each power blip otherwise it could be pointing south and saying it's north.

I suppose you have guessed what I needed with this power supply is some form of battery backup using rechargeable AA batteries. I'm not sure if it would be easy to add to this circuit or it needs a new design.

Whilst it was the weather station that prompted this requirement (there are plenty of them being sold these days), I'm confident that any other device that would lose its configuration on a sudden power loss, no matter how momentary, could benefit from this idea. (N. N., via email).

● As we understand it, it is not necessary for the wind vane itself to be pointed north. The weathervane housing (the part that does not rotate) does need to be orientated north but you only do this once, when you install it. So there is no need to point the wind vane north each time you change the batteries.

Secondly, on some of the weather stations we have seen (eg, from Jaycar) there is a long 4-way phone cable between the weather vane, anemometer etc and the battery holder. So it should be possible to install the battery holder at ground level; no climbing on the roof should be necessary to change the batteries.

Third, if the battery compartment is indeed included in the anemometer housing, then it should be possible to install couple of rechargeable cells and then have them on permanent trickle charge from a small solar panel. This panel only needs to supply a few milliamps at most.

All of which means that you do not need the MiniReg at all for this particular application.

Notes & Errata

6-Digit GPS Clock, May & June 2009: some resistor values on the silk-screened PCB overlay are incorrect (early PCBs only). The resistors shown as 120Ω should be 56Ω and those shown as 270Ω should be 330Ω. The published overlay diagram (Fig.3) is correct.

depends on what kind of transformer you use and how big the case is.

If the transformer is going in the same case, radiation from the transformer could couple into the headphone signal path and produce audible hum at the output. Since this is a low-power application, if you use a small toroidal transformer and keep it away from the headphone amplifier board and input wiring, it will probably be OK. However, make sure you use shielded cable for any signal wiring inside the case and try not to use a small case where everything will be in close proximity.

You can also run the unit from a 15V AC plugpack. This has the advantage of keeping the transformer much further away from the unit. In this case, hum pick-up should not be a problem and also it means that there's no mains wiring.

You can omit the 330Ω resistor. It was only there to compensate for the increased current draw from the

. . . *continued on page 96*

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Ask SILICON CHIP

. . . continued from p94

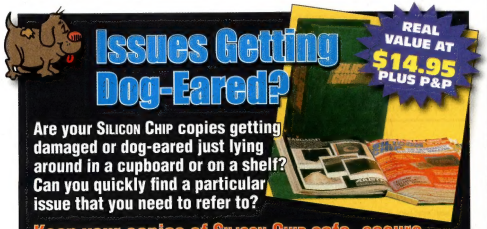
positive rail filter capacitor due to other circuitry in the Studio Series Preamplifier.

Fan cooling for inverter

I have acquired a solar kit out of the February 2008 issue, Oatley Kit K251A. It's for a battery charger but I wish to use the solar panel to drive a cooling fan to cool my PV inverter – obviously for free, ie, sun comes out and my PV-powered fans start, sun sets and the fans stop. Was there a modification to this circuit to make it a PV power regulator rather than a battery charger? (P. D., via email).

● The Solar Power Regulator from February 2008 SILICON CHIP can be used to drive a fan instead of being used as a battery charger. The circuit delivers a nominal 13.8V regulated supply when the solar panel is working, sufficient to drive the fan

You could reduce the supply for a 12V fan by changing zener diode ZD1 to a 10V version, instead of the original 12V, to set the output at 11.8V. SC



Advertising Index

Altronics	76-79
Amateur Scientist CD	87
Avcomm	95
Bitscope	27
Cleverscope	6
Dyne Industries	12
Emona Instruments	8
Futurlec	6
Geoff Coppa	95
Grantronics	95
Harbuch Electronics	8
Hare & Forbes	OBC
Instant PCBs	95
Jaycar	IFC,45-52
Keith Rippon	95
Kitstop	75
LED Sales	95
LHP.NET.AU	IBC
Measurement Innovation	75
Microbee Technology	95
Microchip Technology	3
Mikroelektronika	9
National Electronic Manufacturing	13
Oatley Electronics	33
Ocean Controls	91
Premier Batteries	73
Quest Electronics	95
Radio & Hobbies DVD	93
RF Modules	96
Roc-Solid	5
Rohde & Schwarz	67
Sesame Electronics	95
Sethna Electronics	95
Silicon Chip Binders	96
Silicon Chip Bookshop	69
Silicon Chip Order Form	89
Silicon Chip Partshop	88
Silicon Chip Subscriptions	14
Siomar Battery Engineering	10,95
Splat Controls	95
Switchmode Power Supplies	57
Tekmark	12
Tenrod Australia	7
Truscotts Electronic World	95
Vicom	11
Wiltronics	15
Worldwide Elect. Components	96

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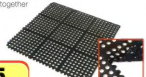

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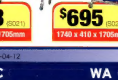

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